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REPORT ON
OBSERVATIONS OF THE MERCURY GROUND RANGE
DURING MERCURY-ATLAS (MA-4) MISSION/

September 11 and 13, 1961

REPORT DATE: ~~October 31, 1961~~

Prepared for
National Aeronautics and Space Administration
on behalf of Western Electric Company, Inc.
by
Bell Telephone Laboratories, Incorporated
on
Contract NAS1-430

FOREWORD

This report contains the observations of the Project Mercury Tracking and Ground Instrumentation System (TAGIS) made during the (F-2)-day network drill and the (F-0)-day launch and orbit of the Mercury-Atlas 4 (MA-4). Primary emphasis is placed on observations made on (F-0)-day, September 13, 961, when the Range tracked the MA-4 capsule. The conclusions and recommendations made by the observers, who were stationed at nine of the TAGIS sites and the LDN and the HON Communication Centers, are also summarized. Observers at seven of these locations were there on other assignments, but acted as observers on the (F-2) and (F-0)-day. Recommendations for future observer procedures are also included. The major observations and resulting recommendations were discussed with Messrs. N. Heller and P. Vavra of NASA and the Network Control Group at Goddard Space Flight Center on September 19, 1961.

The first observations of the performance of the TAGIS equipment when working with the Mercury capsule were obtained by the MA-4 mission. The report also includes a summary of the observations of the performance of the co cation facilities which will be expanded in a report to be issued under NASA Contract NAS5-1434.

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I. INTRODUCTION

On September 11 and 13, 1961, personnel from Bell Telephone Laboratories, Sandia Corporation, and Western Electric Company were stationed, as observers, at the LDN and HON Communication Centers and the following Mercury Range Sites: MCC, GSFC, BDA, ATS, CYI, MUC, GYM, TEX. NASA also provided an observer at WOM. The observers recorded data and submitted reports on the performance as noted at the sites during the (F-2)-day network drill and the (F-0)-launch day of the Mercury-Atlas 4 (MA-4) one-orbit mission of an unmanned capsule.

On launch day, the Mercury Tracking and Ground Instrumentation Range was subjected to its first test with a Mercury capsule. Although the MA-4 mission was a one-orbit mission, all the Mercury network sites except HAW were in contact with the space vehicle at some time. Consequently, the performance of (1) the equipment at the sites, (2) the teletype and voice communications and (3) the computer programs as well as (4) the operating procedures, was demonstrated.

In this report, the method of observation, the conclusions reached, and consequent recommendations are given. Since this was the first opportunity for the network to perform with an orbiting capsule, information concerning actual equipment performance is emphasized.

An observer from the Sandia Corporation was stationed at Bermuda to monitor the performance of the telemetry equipment. His report is summarized in Appendix A.

The schedule of the network activites, that were observed, is as follows:

Date	Time	Test No.	
9/11	06:00-14:00 GMT T-0=12:00 GMT	NCG-444BB	Simulated mission from T-6 hours through one orbit for (F-0) day.
9/13	06:00-16:00 GMT T-0=14:04 GMT	NCG-444	T-6 hours through one orbit.

II. PURPOSE OF OBSERVATIONS

The objectives of the observations made during the MA-4 (F-2)-day network drill and launch (F-0)-day, were to determine: (1) The performance of the range site equipment in tracking a Mercury capsule, (2) the adequacy of the M&O operating procedures, (3) the adequacy of the communications facilities provided for the Mercury Range. This was the first time that the Mercury capsule was tracked by the TAGIS sites, so that data could be obtained on the performance of the acquisition, radars, telemetry, command, capsule voice communications and computers when operating with the Mercury capsule in orbit.

The primary test objectives of the MA-4 mission, with regard to the Mercury Network, as given in OR-1905, Section C, were:

(1) Demonstrate the proper operation of the ground command control equipment.

(2) Evaluate the performance of the equipment and the operational procedures used in establishing the launch trajectory and booster cutoff conditions and in predicting landing points.

(3) Evaluate the ground communications network and procedures.

(4) Evaluate the performance of the Network acquisition aids, the radar tracking system and the associated operational procedures.

(5) Evaluate the telemetry receiving system performance and the telemetry displays.

A secondary objective was to "evaluate and develop Mercury network countdown and operational procedures".

To determine how well the objectives were met, NASA will analyze all site records, as well as records on-board the capsule. The results given in this report represent only the data that were made available to the observers through their own observations when on site and from the several debriefings that were held after the mission.

III. METHOD OF OBSERVATION

Observers were stationed at the sites in accordance with the assignments given in Appendix B. Throughout the scheduled network activity, these observers monitored the equipment and operator performance. These activites started at 06:00 GMT, six hours before the scheduled lift-off and continued through one orbit. The specific network activities were in accordance with the MA-4 Network Countdown issued by GSFC, dated July 25, 1961.

At the conclusion of the (F-2)-day network drill and of the MA-4 mission, each observer transmitted to the Mercury Control Center an observer's TTY report (described in Appendix C) which contained: (1) The duration of important time intervals of site operations, such as the period of "solid" telemetry, (2) the time required to complete the Brief Systems Tests, contained in the count, (3) the time of transmission of Summary, Contact and Status messages, and (4) a brief evaluation of the exercise, including a notation of difficulties and suggestions for changes.

The observers also prepared reports summarizing the TTY mission traffic received at each site from T-0 on (F-2)-day and from T-4:15 on launch day to the end of the drill or mission. These reports, which were sent to Bell Telephone Laboratories for analysis, included a listing for each circuit of the times that all messages were received by the site. It also contained notations of the garbled messages, retransmissions, corrections, and missing messages. The TTY message summary report form is included as Appendix F.

In addition to those reports, a debriefing of the observers was held at Bell Telephone Laboratories on September 18, 1961, at which the observations made at sites were reviewed. The composite observations and pertinent recommendations were presented orally to the NASA Network Control Group and Messrs. N. Heller and P. Vavra of NASA at the Goddard Space Flight Center on September 19, 1961. The data obtained were analyzed further and the results obtained are reflected in this report. These results confirmed the earlier conclusions.

IV. CONCLUSIONS

The performance of the Mercury Range satisfied the needs of the Mercury task very adequately during the successful MA-4 mission, and the Network tests objectives were met. The problems listed under Network Observations can and, undoubtedly, will be eliminated. Many will disappear with increased experience of the operating teams and, in some cases, through improved procedures.

The range and accuracy of the radars, when properly operated, were appropriate to the needs of the Mercury mission. The accurate determination of the orbit and the impact prediction point by the GSFC computers, using the radar data from the sites, substantiates this conclusion. However, only two of the six C-band radars and four of the seven S-band radars, that were in range of the capsule, provided any substantial radar data. This difficulty is ascribed to radar operator performance and procedures. Further radar operator training in procedures is definitely necessary. It is apparent that the role of each human operator is primary.

The GSFC computers operated very satisfactorily and the location of the capsule was known at all times. The Impact Point, determined by the GSFC computer, was about 1 mile from the point where the recovery ship recovered the capsule. This also implies that the location of the sites, whose radar data were used, is known quite accurately.

The range performance of the Acquisition Aid was good with all sites (except HAW, which was out of range) tracking the capsule, generally from horizon to horizon. The acquisition bus procedures, as noted under radar, require investigation and improvement.

The telemetry subsystem operation was very satisfactory. Very strong signals were reported and telemetered data were generally received from horizon to horizon. There was good agreement among sites as to the values of telemetered quantities.

The performance of the air-to-ground voice subsystem, on both HF and UHF, was excellent during the period when the capsule was transmitting. The capsule stopped transmitting between WOM and CTN because of a failure of the on-board tape playback transmitting system.

Although the retro-rockets were fired by the capsule clock, the Command subsystem was reported to have operated well in tests conducted during the re-entry whenever the range to the capsule was less than about 400 miles.

The timing subsystem operation was reported as being satisfactory at all observed sites, except for a minor problem of timing marks not appearing at the radar plotboard at Bermuda.

The Teletype system performed well during the MA-4 mission, including the automatic rebroadcast TTY equipment (83B2) at GSFC. The voice circuits were good with the exception of the low voice level reported from the Woomera site. The high speed data circuits between CNV and GSFC were quite adequate throughout the mission.

Reports on the performance of the M&O teams at all sites were generally favorable with the exception of the difficulties with the radar teams noted above. It was apparent that at the radar sites (CYI and MUC) where RAZEL simulation equipment had been used extensively, the radar performance was notably better than the other sites where this equipment was not used or was not available.

In general, the TAGIS personnel and equipment passed the MA-4 test with high grades. Since the grades were not 100%, the next section contains recommendations, for improving the performance of the Range, that were prompted by the observations made during the tests.

V. RECOMMENDATIONS

In this section a brief statement of each recommendation is given. At the end of each statement, a number is given corresponding to the paragraph number in the report in which the observation supporting the recommendation is described.

The recommendations are divided by subject matter into (A) Equipment, (B) Procedures, (C) Personnel and Training and (D) Observation Procedures.

A. Equipment

1. Computer Program

a. The Bermuda and GSFC computers should be programmed for better utilization of the VERLORT and FPS-16 radar data regardless of which radar is the best performer during the mission. (VI-A-1-b).

b. The intermittent display of ECTRC and associated recovery area at BDA should be corrected. (VI-A-1-b).

2. Command

a. The adequacy of the on-site spare parts for the command system should be reviewed. (VI-A-2).

3. Acquisition

a. A test should be made of the Electrospan link at Bermuda to locate the cause of its erratic operation. The Town Hill-Cooper's Island cable should be checked for crosstalk to determine if this may be the cause for the errors reported on the acquisition bus. A realignment and retest of the entire acquisition bus system should be made. (VI-A-3-c).

b. Provide a modification kit to all VERLORT sites to remove the problem of the line amplifier being loaded down and causing the remote synchro receiver to act as a source. (VI-A-3-f).

c. Provide a modification kit to eliminate the recurrent feed-point breakage problem of the helices of the AR and R antennas. (VI-A-3-b).

4. Timing Subsystem

The reliability of the timing marks on the radar plotboard at BDA should be improved. These marks were reported "lost" once during the simulation exercises and also on mission day. (VI-A-5).

5. Telemetry Subsystem

Investigate the telemetry records and determine the cause of the discrepancy with other sites of the "capsule clock" readings at IOS and ATS and the "fuel quantity" reading at ATS. (VI-A-6-b).

6. Radar Subsystem

a. Consider the replacement of the MPQ-31 S-band radar at EGL with an existing MPS-19 radar. (VI-A-7-a).

b. Investigate the reliability of the pump klystron for the VERLORT parametric preamplifier at BDA and supply additional spares if deemed necessary. (VI-A-7-b).

c. Investigate the failure at EGL of the "valid" bit to change to "invalid" in the radar data messages when automatic range tracking was lost. (Appendix E).

d. Re-examine the logic, and associated logic circuits, for inserting the "valid bit" in the radar data messages. (VI-A-1-b).

e. Develop a modification for VERLORT radars to indicate proper choice of range interval. (Appendix D).

B. Procedures

1. Communications

a. Test the Goddard Conference (FP #1) voice levels at least weekly; expand this test to include measurements of the over-all voice loop from the console at one site to the console at the others. (VI-B-1-a).

b. Improve the procedures for voice circuit trouble reporting between GSFC and WASH 1. (VI-B-1-b).

c. Provide the GSFC Communication Director with a report on the status of critical coverage of communication facilities at T-6:00 on (F-2)-day and (F-0)-day. (VI-B-1-c).

2. Acquisition Aid and Telemetry

a. Change mission documentation conerning telemetry signal strength recordings to reflect the MA-4 experience. (VI-B-2-a).

b. Establish the procedure that the Acquisition Aid operator track manually in elevation at elevation angles below 10 degrees. (VI-V-2-c).

c. Instruct sites to monitor and adjust levels of the telemetry tape recorders more frequently. (Appendix A).

d. Determine empirically whether the telemetry decommutator should be operated with or without the Zero and Gain correction servos by using the telemetry tape recorded at BDA during the MA-4 re-entry. (Appendix A).

e. Provide all sites with information for annotating the telemetry pen recorders as required in the MA-4 Data Acquisition Plan. (Appendix A).

3. <u>Radar</u>

a. Provide more detailed radar handover procedures to the sites involved. (VI-B-3-a and VI-B-3-f).

b. Require the WOM FPS-16 radar to participate in some, if not all, network drills preceding a mission. (VI-B-3-a).

c. Collect radar teletype (28 RO) print-out at sites after each mission for post-mission analysis. (VI-B-3-b and Appendix D).

d. Standardize the procedure for adjusting radar servo amplifier gain. Perform this adjustment in the pre- and post-mission calibration. (VI-B-3-c).

e. Review procedures for measuring the mid-frequency of the radar for interrogating the capsule beacon. Consider the elimination of this frequency from SUM messages if required measurement time is too long. (VI-B-3-d and VI-B-3-e).

4. <u>Documentation</u>

A. Distribute additional copies of DST's and BST's to sites as soon as possible. (VI-B-4-a).

5. <u>Reports</u>

a. Include in the Mercury Operations Directive, 61-1, a section entitled Reports, that describes the reports required from the sites during "down mission", "up mission" and "post mission" periods. (VI-B-5).

6. <u>Countdown</u>

a. Consider the following changes in the Mercury-Atlas Network Count:

(1) Provide two 30-minute CADFISS - option periods starting at T-2:10 and T-0:50. High speed checks, Roll Call reruns or Data Flow tests (following extensive holds) would be run during these periods at the discretion of the Network Status Monitor. (VIII).

(2) Delete the requirement for a second BST-108 (Teletype) because the teletype equipment performance is being monitored continuously.

(3) Include slew checks (abbreviated series 90 tests) in the CADFISS Roll Call if feasible. (VIII-C).

C. <u>Personnel and Training</u>

1. <u>Personnel</u>

a. Establish a "cutoff date" for site personnel changes of approximately three weeks prior to a mission launch date. A knowledgeable operator should be able to achieve acceptable proficiency on his assigned equipment and learn Mercury procedures in this time. (VI-C-1).

b. Provide assistance to the M&O Supervisor to relieve him of certain administrative tasks so that he can devote more time to operational and training duties. (VI-C-2).

2. Training

a. Provide VATS simulation equipment at all sites to permit realistic simulation training of acquisition, A/G radio, and telemetry personnel.

b. Provide RAZEL equipment for training of radar crews at all sites with S-band radars. Develop and provide a RAZEL-type equipment for the FPS-16 radars. The markedly better performance of the radar teams at CYI and MUC can be ascribed, in part, to the realistic simulation obtained by using the RAZEL equipment. (VI-B-3-a).

c. Schedule site and network drills on a periodic basis, between missions, to maintain personnel proficiency. To provide realism, require the use of VATS and RAZEL simulation equipment during such drills and, in the case of network drills, provide sites with simulation plans for setting up the VATS and RAZEL equipment.

d. Provide the sites with final instruction manuals, DST's and BST's for the VATS and RAZEL equipment.

e. Continue to use the Mercury Test Aircraft for periodic site training as well as dynamic testing. (VI-C-3).

f. Establish formal procedures for evaluating site equipment and M&O personnel performance during network drills and live missions. Provide sites with evaluation reports to permit corrective action if required.

D. Observation Procedures

1. It is recommended that the NASA group charged with supervision of the Mercury Range deploy observers to sites for future Mercury missions. Observation procedures similar to those employed in the MA-4 mission still appear appropriate.

2. The observation period should coincide with the Flight Controller site activities. The time spent on site prior to the launch day produces valuable recommendations that can improve the present and future missions.

3. The following additional facilities are recommended at MCC to facilitate performance monitoring:

a. Locate two communication monitor positions beneath the viewing area of the Operations Room. One position would be responsible for monitoring the local site loops and the other position would be responsible for monitoring the network loops.

b. Provide a multi-channel tape recorder for the communication monitors; four channels would be used to record (1) GSC, (2) FP #3 and (3) FP #5 loops and (4) observer's comments for analysis after the mission.

4. To increase the usefulness of the observations, the equipment performance recordings, obtained from each site, should be made available to be analyzed by the NASA Range group. In this way, the kind of analysis given in Appendix D can be performed to indicate how the several systems at a site were operating.

5. The Date-Time-Group convention for the teletype messages used during the MA-4 mission should be continued. The start-of-message Date-Time-Group indicates the time of message delivery to the communication center and the end-of-message time group indicates the time when the teletype operator completed punching the message tape.

VI. NETWORK OBSERVATIONS

In this section, the observations made during the (F-2)-day network drill and the (F-0)-day MA-4 launch of September 11 and 13, 1961 are summarized. They are categorized as (A) Equipment, (B) Procedures, and (C) Personnel and Training. The observations of the performance of the teletype system, CADFISS tests and telemetry system are given in Sections VII, VIII and Appendix A, respectively.

A. Equipment Observations

1. Computer

a. Goddard Computers

The GSFC computers operated properly throughout the NCG-444 mission and the location of the capsule was known at all times.

As programmed, no use was made of data from the Bermuda VERLORT in the on-line computers (A and B). These data were used successfully in the off-line computer (C) in the "short arc" computation and would have been used in restarting the on-line computers if no radar data had been received from CYI. The Impact Point determined by the GSFC computer (32° 11' N, 61° 52' W) was about 1 mile from the point where the USS Decatur picked up the space vehicle (32° 11' N, 61° 53' W) as determined by the ship's LORAN equipment.

b. Bermuda Computer

The computer at BDA was late in providing its GO-NO GO decision in the NCG-444 mission. This was due, in part, to the lateness of the FPS-16 radar in obtaining valid track (T + 5:31) as well as the receipt by the computer of some erroneous VERLORT data which were still marked as "valid". The errors in data resulted because the VERLORT was not in automatic elevation at this time. In addition, some computed quantities (ECTRC and the associated recovery area) were only displayed momentarily. These were suspected to be the result of a program problem. One observer reported that during simulated missions the FPS-16 was considered the prime computer control. Since the FPS-16 data were sent during the first mission pass, effective use was therefore not made of the long period of VERLORT valid tracking. Since the computer did not receive radar data during re-entry, it did not compute the final Impact Point.

2. Command Subsystem

a. Since the retro-rockets were fired by the capsule clock in the MA-4 mission, the information on the performance of the command system must be obtained from the records that were made in the space vehicle, and the records at the sites that sent commands, namely GYM, MCC and BDA. The results of the detailed analysis of these records are not known by the observers, although the command equipment was reported working and CNV reported that their ground records indicated that the appropriate commands were transmitted.

b. At Guaymas, prior to the (F-2)-day network drill, a command transmitter had a DC breakdown in the final RF stage, because of a shorted capacitor. As no replacement part was available at the site, emergency repairs were made; a replacement part was flown from CNV to Tucson for pickup by the site personnel. The new capacitor assembly was installed and checked out at T-16 hours of (F-0)-day.

3. Acquisition Subsystem

a. The performance of the Acquisition Aid is described by noting that all sites received telemetry from the space vehicle (except HAW which was out of range); even CAL (which is the next most remote site from the trajectory) had telemetry contact for 4.2 minutes. As expected, the Acquisition Aid automatic tracking at low elevation angles was rough in elevation but tracking was generally from horizon to horizon.

b. At BDA, the Acquisition Aids at Town Hill and Cooper's Island performed satisfactorily as far as signal sensitivity was concerned. It should be noted that a parallax problem will exist if the Town Hill Acquisition Aid is used as the source of pointing data during a pass to the South of BDA such as occurs during re-entry.

The Cooper's Island Acquisition Aid developed a loose antenna feedpoint during the first pass leading to a series of radar acquisition problems but this condition was corrected by 15:35 GMT for use during re-entry. It was stated by the observers, that except for the antenna feedpoint problem, the Acquisition Aid equipment and personnel performed in an acceptable manner during the MA-4 mission.

c. Despite the satisfactory performance of the BDA Acquisition Aid and Telemetry subsystems, late acquisition of the vehicle by the radars occurred at Bermuda. Thus, although TLM was solid at BDA at T + 3:04*, the first valid radar track (FPS-16) was not until T + 5:32. Moreover, although the Bermuda Acquisition Aid and the VERLORT radar were tracking, the FPS-16 did not reacquire the capsule after it lost track at T + 6:08 even though the Acquisition Aid continued to track until T + 10:22 and the VERLORT tracked until T + 10:14. It appears that the Acquisition Data subsystem and bus equipment and procedures require examination. The Electrospan link from Town Hill to Cooper's Island continues to be erratic in operation. It was the observer's opinion that crosstalk may be creating this disturbance.

d. At IOS, it was reported that the coaxial fittings on the Acquisition Aid antenna hybrids (UHR 5-7) were corroded. This was possibly because the modification for sealing these connectors against moisture was not added until six months after installation. A temporary repair was completed by mission time and new hybrids were ordered.

e. The observer at GYM reported that the Acquisition Aid and Telemetry acquired and locked on without problems. At 10:17 GMT on mission day, the "R" antenna pedestal was reported as not following the servos. The trouble, located upon

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*Time after lift-off is given in minutes and seconds.

examination of the antenna, was that a limit switch had failed causing the antenna to go through the mechanical stops and pulling the cables from their terminals. The operator could have prevented this problem by knowing the extent of the cable wrap and limit switches and observing his dials. The RF and synchro cables were repaired and replaced in time to participate in the mission.

f. The VERLORT radar at the Canary Islands lost signals at an outgoing range of about 215 nautical miles. At this time, reacquisition was attempted by slaving to the acquisition bus whereupon the radar slewed to an azimuth position approximately 180° from the bus information.

The following sequence of events is believed to have caused this behavior. Initially, the Acquisition Aid supplied the acquisition bus with pointing information which was used by the VERLORT radar and the remote synchro azimuth dial in the VERLORT van. When the VERLORT started tracking at approximately 745 nautical miles, the VERLORT was switched from the acquisition bus and the input to the remote dial in the radar van was disconnected. During this period, the VERLORT tracked through an azimuth angle of approximately 160°. When the VERLORT lost track, the Acquisition Aid was designated as bus source and the VERLORT was slaved to the bus; the remote dial at this time was approximately 175° from the true bus information. The line amplifier was loaded down by this remote dial (synchro receiver) and the receiver acted as a source and positioned the VERLORT radar approximately 180° from the true bus position. This problem is believed to exist at all VERLORT locations. Following the mission, the CYI personnel confirmed this speculation and suggested changes to eliminate the trouble.

4. Capsule Voice Subsystem

a. The performance of the air-to-ground voice subsystem on both HF and UHF was excellent until the capsule stopped transmission after Woomera. At all times, in this interval, the capsule was being heard by at least one site (cf. Figure 6-3). It should be noted that the MA-4 mission was the first time that the HF voice was received satisfactorily from a Mercury spacecraft since no HF had been heard from the prior Redstone capsules.

5. Timing Subsystem

The network timing subsystems operated well during the missions with the following exceptions:

a. At BDA the timing marks on the radar plotboards and on one channel of a telemetry Sanborn recorder were lost shortly before launch, resulting in a brief hold. This hold was called because it was indicated that there would be no timing information on the radar data sent to GSFC. BDA quickly confirmed that the radar teletype timing data were satisfactory and the count was resumed. The radar plot timing marks were not restored during the mission but suitable manual annotation was made on the VERLORT radar plotboard.

b. The AMR countdown clock at MCC developed an error of 1 minute at lift-off.

6. Telemetry Subsystem

a. The performance of the telemetry subsystem was very satisfactory. Very strong signals were reported, for example, 600 microvolts maximum at BDA, and the horizon was the only limitation to receiving telemetry at most sites. Telemetry was being received from the spacecraft for all but 25 minutes, of its 90 minute flight, of which 3 minutes was caused by blackout during re-entry (cf, Figure 6-1). The major portion of this gap in coverage occurred between WOM and CTN (7 minutes) and between CTN and CAL (9 minutes) since the spacecraft was well below the horizon of these sites for these periods.

b. All telemetered quantities appeared to have been received correctly with two exceptions:

(1) The IOS and ATS "capsule clock" readings differed from those of other sites by 1 second.

(2) A "fuel quantity" reading at ATS was approximately 5 per cent higher than from other sites.

c. Figure 6-1 indicates telemetry coverage during the MA-4 mission. The data were obtained from the observer reports except that, for sites without observers, the information was taken from the "PLIM" messages.

7. Radar Subsystem

The radar subsystem experienced the most difficulty during the MA-4 mission. Specifically, the record, by site, of valid track is shown on Figure 6-2. The plotted data were obtained from the observer reports except at sites where there were no observers and the "PLIM" message data were used.

a. The only radar that was not operating at lift-off on (F-0)-day was the MPQ-31 at EGL which had a defective transmitter.

b. The BDA VERLORT radar parametric preamplifier was not working so the standard configuration of the VERLORT was used. The pump klystron and the spare klystron for this equipment had failed.

c. At GYM, the radar receiver had a tube failure, during the countdown for (F-2)-day network drill, which shorted out some resistors. These were replaced and the receiver was back in operation in time for the simulated launch.

d. The difficulty of determining, after a mission, the actual radar performance during the mission suggests that a method be found in which the sequence of radar events are recorded. It is proposed that the 5th character of the radar teletype 28 RO, now being used only to denote validity of data, also be used to indicate "manual" or "automatic" mode, and "acquisition bus" mode in order that the radar tape provide the desired record.

e. Because only minor radar equipment problems were reported in completing the Detailed and Brief Systems Tests, the more probable reasons for the poor performance of the radar subsystem at several sites are operator procedures and experience as discussed in Section VI-B.

8. <u>Ground Communications Subsystem</u>

a. Teletype Equipment

The performance of the teletype equipment at the observed sites was excellent during the MA-4 mission, (F-0)-day; there were no equipment troubles reported.

During the (F-2)-day network drill there were two minor equipment troubles at MCC. The 28 RO Teletype machine behind the trend charts was inoperative for about 10 minutes and the 28 RO machine on Circuit #19 was inoperative for about three minutes. The troubles were quickly located and cleared by the on-site personnel.

The ATS Point-to-Point HF receivers were reported to have a noise problem due to arcing when ATS is transmitting.

b. Teletype Circuits

The teletype circuits performed satisfactorily during the entire exercise. The CADFISS test of the relay of CYI data through ATS was passed successfully for the first time on (F-0)-day. Difficulty was experienced in initially setting up this alternate circuit. The trouble was recognized to be in the Canary Island end of the circuit and additional instructions have been issued which, it is hoped, will remove it.

Communications losses were experienced at the following sites during the MA-4 launch day (NCG-444):

1. Texas lost communication for 10 minutes during the countdown at 8:33 GMT.

2. California lost communication for 3 minutes at the same time as Texas so that it failed some tests in the CADFISS Roll Call. These tests were subsequently repeated successfully.

3. ATS lost communication for about 2 minutes at 12:28 GMT.

4. GYM reported some garbling of messages for about 5 minutes at 14:49 GMT (T + 45 mins.) but no loss of communications.

5. The major circuit loss was on the Sidney to Vancouver cable (circuit 01) which was out for 1 hour, 11 minutes (8:44 GMT to 9:55 GMT) due to phasing troubles.

In general, despite a poor-to-fair propagation forecast, the teletype network performed better than in any other previous exercise.

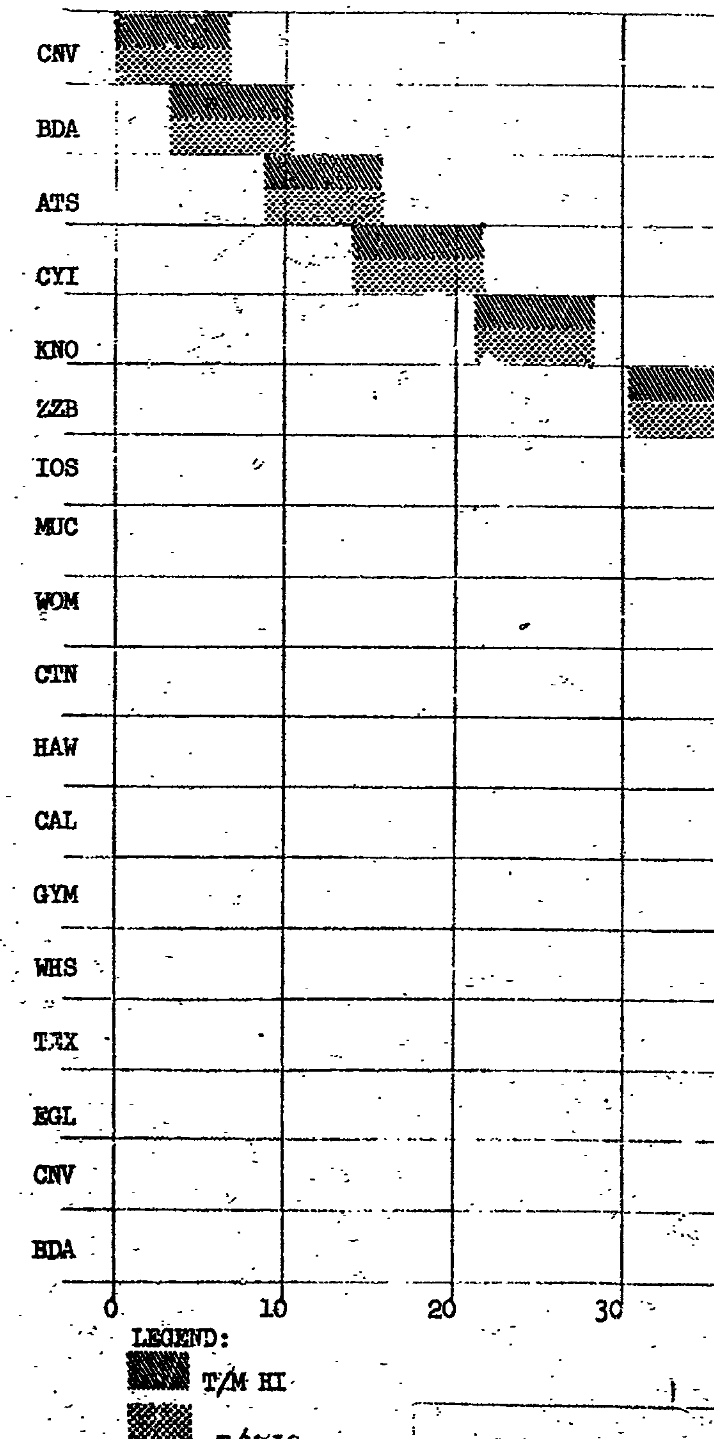
c. <u>Voice System</u>

The Voice Communication Network was much improved over previous exercises, but still had some problems. The voice network was mainly "loud and clear", but at one time, threatened to hold the launch when GYM responses to MCC were not heard at MCC. The trouble was located in a key in the SCAMA board at GSFC. The trouble was cleared prior to launch by patching to by-pass the defective key.

Another difficulty reported was the weak reception from Woomera. This was later found to be in the land lines between Adelaide and Woomera.

The monitor level appeared to drop at Bermuda when SCAMA switched talk capability to the western sites. While this condition is not enough to be considered serious, it is felt that a system level adjustment before each mission would improve the entire voice network.

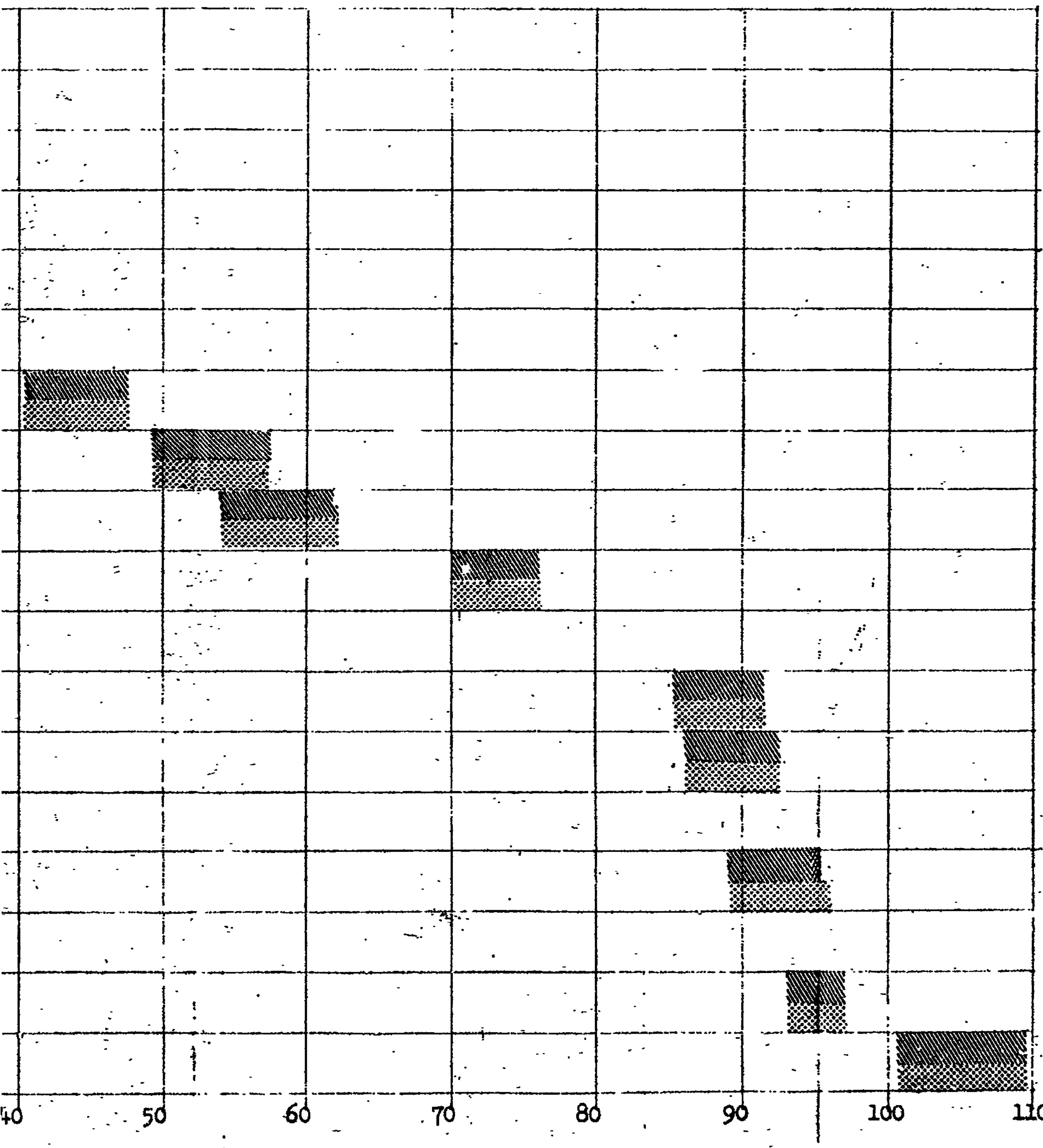
The only reported loss of voice communications between MCC and GSFC was for about 1 minute at 15:45 GMT.



Information obta.

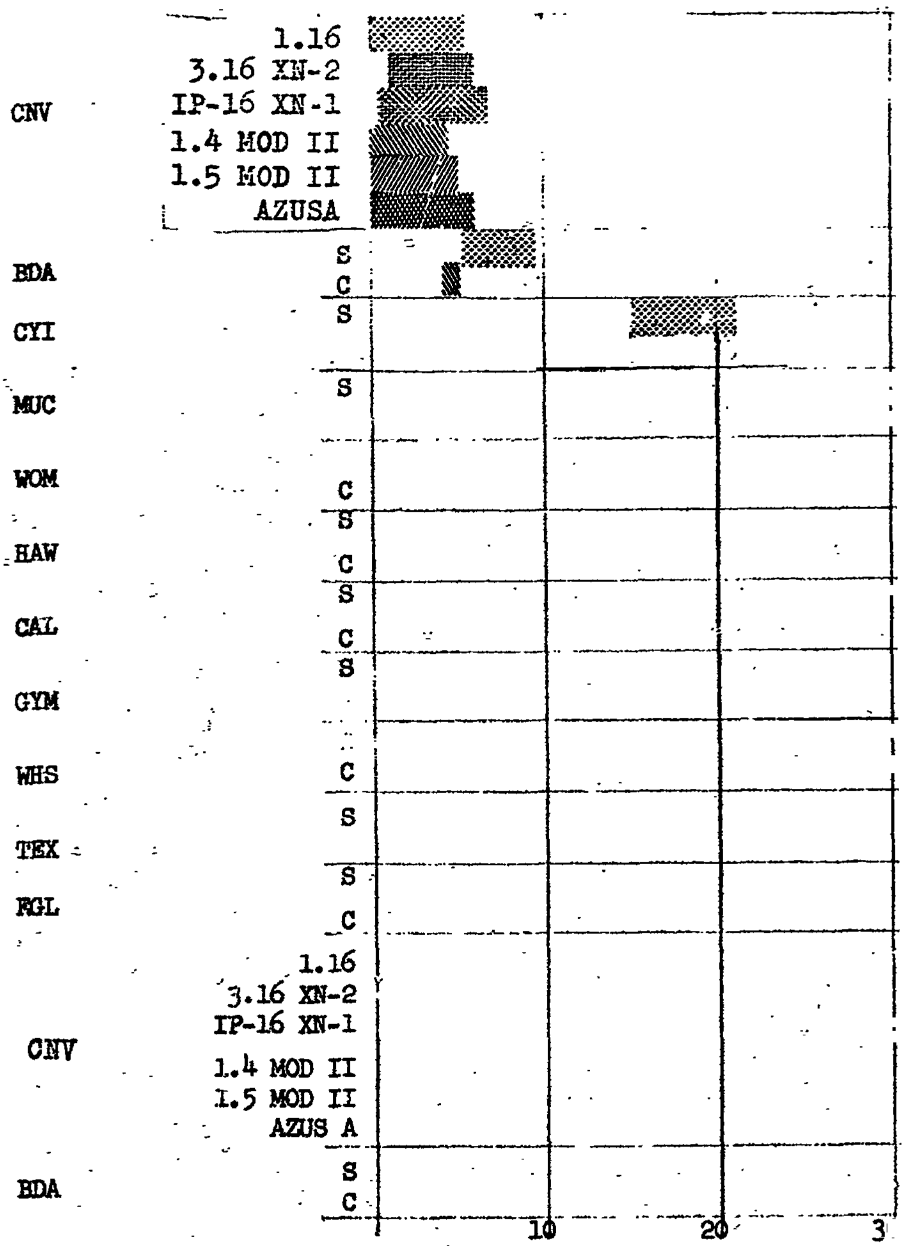
2

FIGURE 6-1
TELEMETRY COVERAGE
TEST NCG 444



TIME FROM LIFT OFF - MINUTES

from "Observer Reports" and "PLIM" messages.

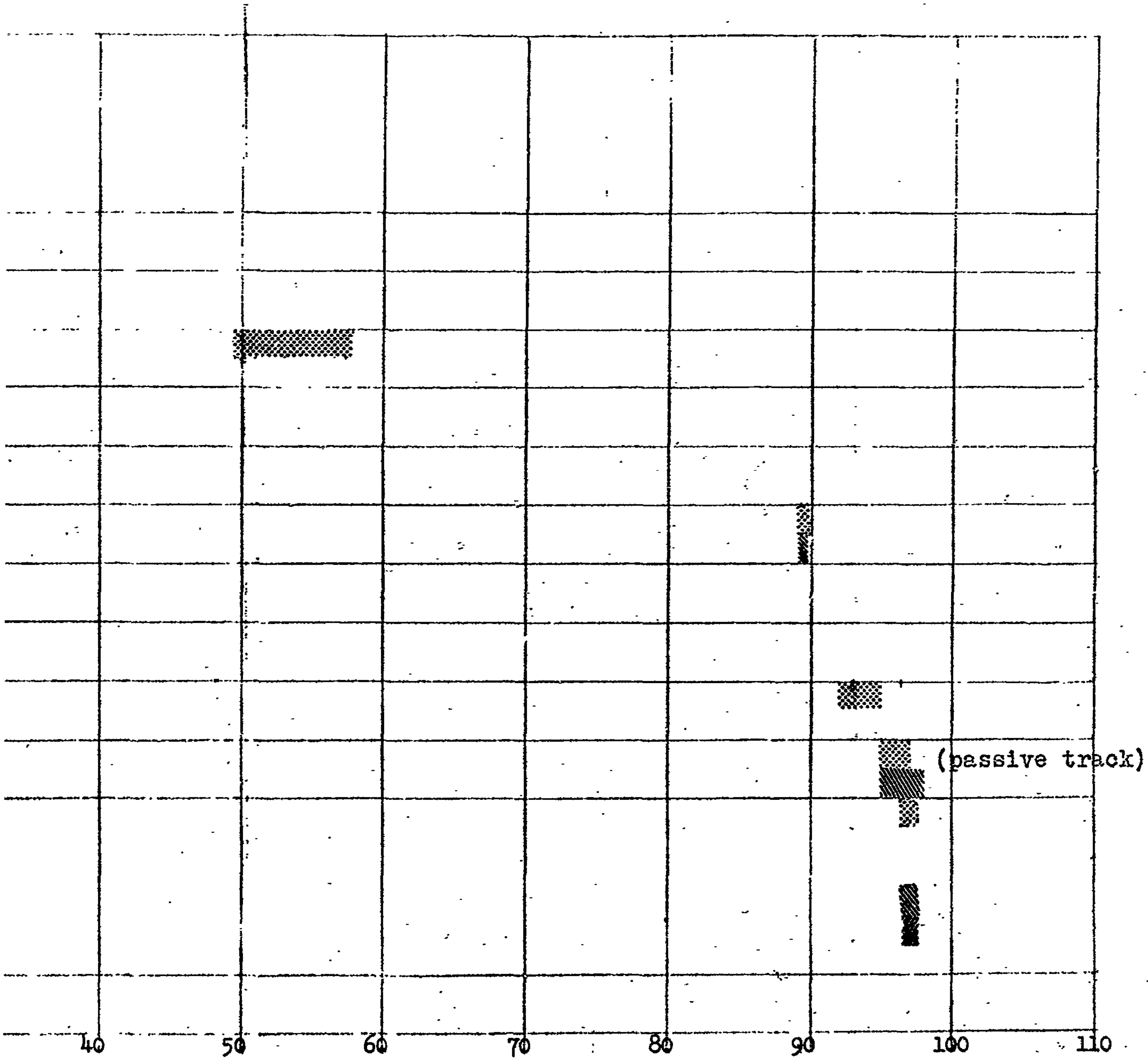


CNV
1.16
3.16 XN-2
IP-16 XN-1
1.4 MOD II
1.5 MOD II
AZUSA
BDA
S
C
CYI
S
MUC
S
WOM
C
HAW
S
C
CAL
S
C
GYM
S
WHS
C
TEX
S
RGL
S
C
CNV
1.16
3.16 XN-2
IP-16 XN-1
1.4 MOD II
1.5 MOD II
AZUS A
BDA
S
C
10
20
3

Informati

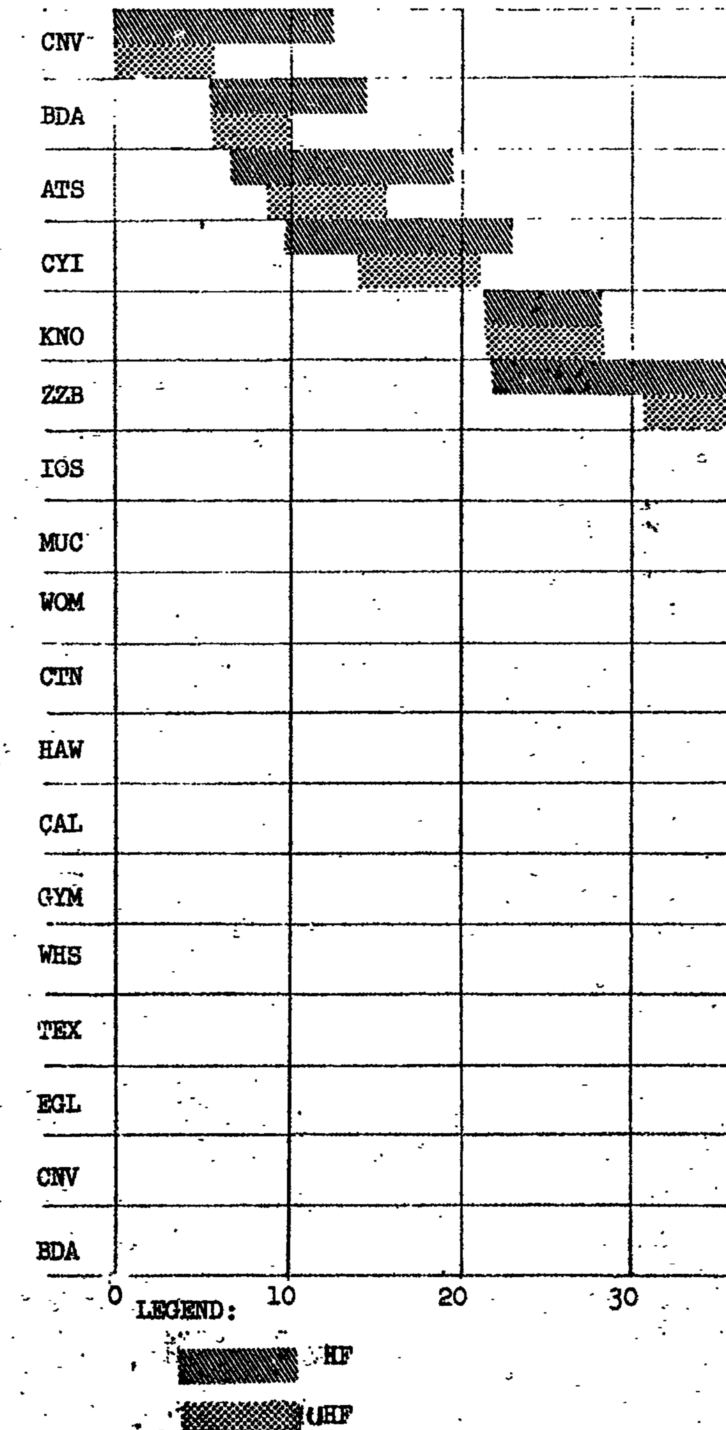
2

FIGURE 6-2
RADAR COVERAGE
TEST NCG 444



TIME FROM LIFT-OFF - MINUTES

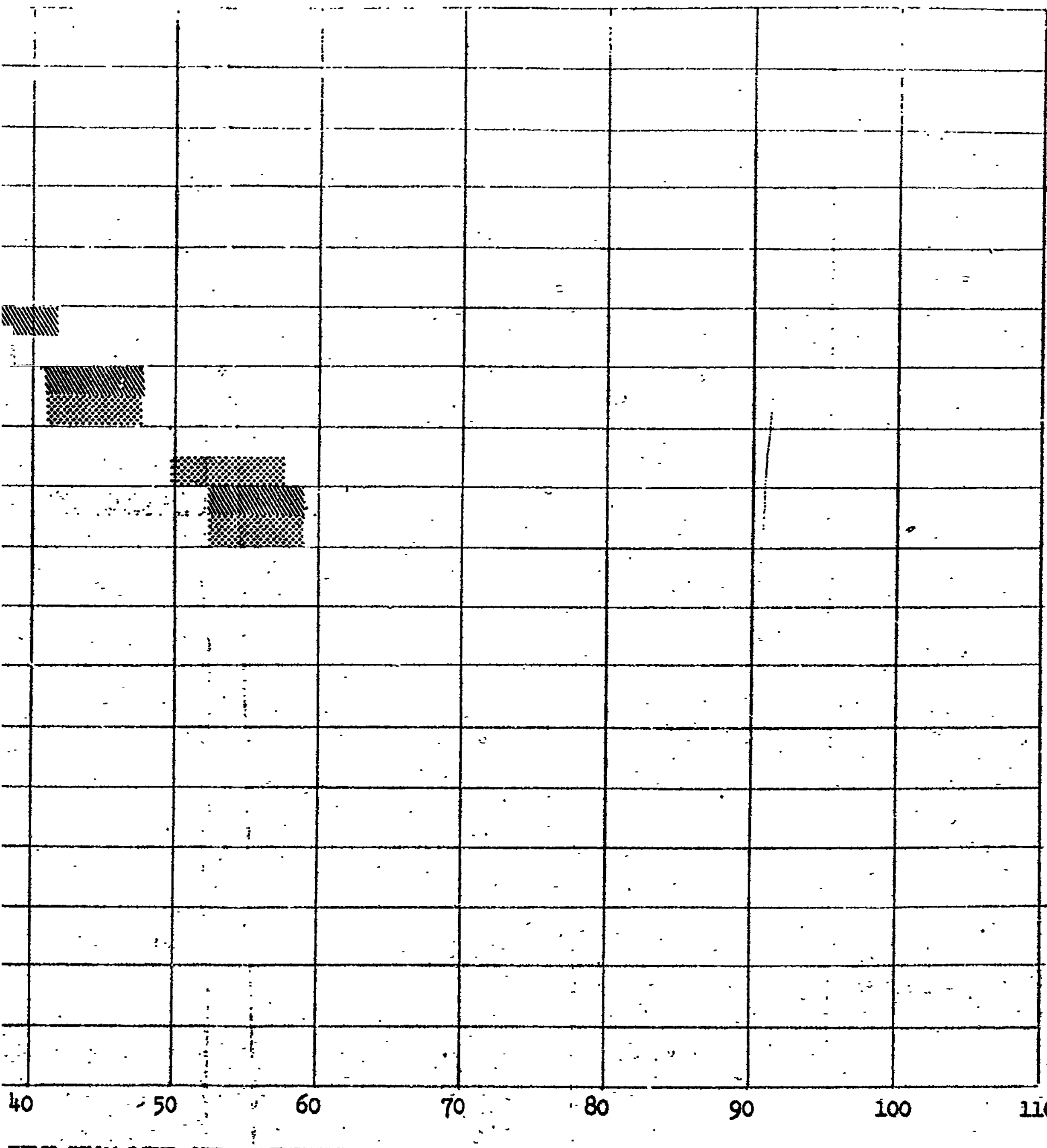
tained from "Observer Reports" and "PLIM" messages.



Information obtaine
(capsu

2

FIGURE 6-3
PSULE VOICE COMMUNICATIONS COVERAGE
TEST MCG 444



rom "Observer Reports" and "PLIM" messages
stopped transmitting after WOM).

B. Procedures

1. Communications Procedures

a. Observers reported that the Goddard Conference Circuit (FP #1) transmission levels are not consistent from site to site. The high level from MCG experienced during the August drills was reduced, but the voice level was low from WOM on (F-0)-day. The Flight Director reported WOM as unreadable during parts of the plus-time mission.

b. The GYM voice transmissions on the GSFC Conference Circuit (FP #1) were intermittently "blocked" to MCC during the launch count. The problem persisted for about two hours. Although the defective equipment, a key in the GSFC SCAMA board, was not located until after the mission, a patching change was made that eliminated the problem about 30 minutes before launch.

A solution might have been obtained more expeditiously if, (1) GSFC had reported the problem to WASH 1 without delay and (2) the initial test effort by WASH 1 had been more thorough since the first report erroneously stated that the difficulty was at GYM.

c. The extent of the launch-day "critical coverage" was not known to personnel at GSFC or MCC. No reports were required to indicate whether "critical coverage" was in effect or not.

d. Changes in mission documentation were made by ISI's. Discrepancies occurred because of different "line counting" methods employed by the originators and the recipients of SVC messages sent to correct ISI messages. Since MG-102-15 defines the "text" as the "message classification (e.g., BRF) plus the body", confusion results when reference is made only to lines in the text in correcting messages.

e. The TTY system did not receive Acquisition messages during re-entry in Test NCG-444. Apparently, the output of the computer in the re-entry mode was not connected to the TTY system when the computer was generating AQ messages for the U.S. sites. The computer print-out indicates the re-entry mode AQ messages for BDA were generated approximately five minutes after re-entry computations began; these messages were blocked by the operators at GSFC because of inappropriate instructions.

2. Acquisition Aid Procedures

a. The capsule telemetry signal strength received by ground stations was considerably higher than the pen recorder full scale setting (7 microvolts) specified in the Data Acquisition Plan.

b. The acquisition bus was not used at several sites for re-acquisition of the capsule when tracking was lost during the pass.

c. Some sites commented that the automatic elevation tracking of the acquisition aid was rough at low angles, as expected, because of multipath effects. Other sites indicated that such rough tracking was overcome by using manual elevation track below 10 degrees elevation.

3. Radar Procedures

a. A digest of the observer reports and other information obtained on site radar performance follows:

BDA

The Bermuda observer reported that the FPS-16 had approximately 20 seconds of valid track during the first pass of the capsule and none during the re-entry. A review of the AGC record indicated a highly fluctuating received signal strength that may have resulted from lobes in the capsule's antenna pattern.

It was the observer's opinion that the Bermuda FPS-16 radar crew needs considerable training in the acquisition and tracking of targets whose trajectories generate high rates of azimuth, elevation and range. This could be done by use of an instrumented aircraft and/or the development of a radar simulator, like the RAZEL, for the FPS-16 radar.

The VERLORT radar provided 4 minutes of solid track during the first pass of the capsule. The parametric preamplifier was not operating during this mission.

During the re-entry phase the VERLORT operators saw bursts of "rabbits" three times, but could not acquire track. The capsule had been acquired and tracked by the Town Hill acquisition aid. Despite this, it was noted that the data source used for radar acquisition was the manual input handwheels. The operator explained that the Electro-span equipment was not functioning properly and that the ADC operator was manually following the Town Hill indications. This was evidenced by erratic movements in both azimuth and elevation. It was the opinion of the observers that, if the acquisition bus had been operating properly, the probability of acquisition by the radar would have been greatly increased.

The Bermuda VERLORT radar did not participate in Test NCG-444BB. Although RAZEL was available, priority was given to maintenance of the synchro circuitry associated with the acquisition system.

WOM

The cause of the absence of tracking by the FPS-16 radar during Test NCG-444 is not known. The radar was checked after the pass, indicating it was operating properly. Operator inexperience is suspected to be the cause of the trouble as it was the first time the site attempted to track an orbital velocity target. It should be noted that this radar was not made available for any of the network drills in either August or September when the MA-4 mission was simulated.

GYM

The observer reported that the GYM VERLORT radar was unable to acquire and track the capsule in Test NCG-444 for unknown reasons. The radar operators indicated that they manually searched in range and frequency and saw the capsule signal but could not lock on when they switched to automatic frequency control, indicating a possible operator error in adjustment of the radar receiver.

TEX

The TEX observer reported that there were trouble areas in the radar equipments, procedures and operations. An analysis of the radar data transmitted to GSFC from the TEX VERLORT radar during the MA-4 mission (NCG-444) is included as Appendix D of this report.

The analysis indicates that the capsule was acquired and tracked but was lost when the radar was coasting through the transmitted pulse in accordance with the radar handover procedures. At the same time, the elevation encoder apparently failed so data sent to GSFC were in error. On re-acquisition, the transmitted range was in error by one range interval, because of an operator error. It is also apparent that no use was made of the acquisition bus when the radar lost track.

EGL

Active tracking by the FPS-16 radar was reported to have been late in starting because of the uncertainty as to whether the radar handover procedures permitted it. Nevertheless, the data obtained were of good quality and permitted the computer to make a good determination of the Impact Point of the capsule. An analysis of the radar teletype data transmitted to GSFC from EGL is enclosed as Appendix E.

b. In future missions, the tape from the radar 28 RO teletype machine should be collected as part of the mission data. This tape contains radar position data regardless of whether the radar is in valid track or transmitting to GSFC. Analysis of this record would establish actual radar positioning and operator performance.

c. A standardized procedures for adjusting the radar servo amplifier gain is required. Some sites report that adjustment is made by "feel"; other sites use the function recorders for a "volts per mil" change; and a third method is adjustment for proper overshoot.

d. Cape Canaveral reported that the determination of the radar mid-frequency required to interrogate the capsule beacon is not accurate because of the short time that the capsule beacon is available for this measurement and the warm-up time of the capsule beacon. During the internal power checks of the capsule prior to launch, there is not sufficient time to recheck the interrogate frequency but only time to check for signal strength similar to that when the capsule beacon is on external power.

e. Many sites reported that there was not sufficient time to check the radar interrogate mid-frequency and, therefore, the value given in the Summary (SUM) message report was one they had previously received.

f. Observers at the sites involved reported unsatisfactory operation of the radar handover net. The GSFC conference loop was in almost continual use by the Flight Controllers during the S-band radar handover period during Test NCG-444.

It has been reported that the S-band beacons used in the future spacecraft will not have a lockout problem, so that several radars can interrogate the beacon with negligible interference. If such beacons become available, the handover procedures should be re-examined and simplified to minimize the requirements for a radar S-band voice circuit. If such beacons are not available, independent voice communications for S-band radar handover should be established and a Radar Controller should be stationed at MCC to coordinate the handover procedures.

g. The Cape Canaveral S-band radar operator was not informed that the Eglin MPQ-31 radar was inoperative. This indicates a communications problem within AMR.

4. Documentation

a. More copies of the latest issues of the Brief System Tests and Detailed System Tests are required at the sites since the copies provided have been used.

b. The ISI technique for issuing instructions or for changing mission documentation appeared satisfactory. The large number of ISI's issued in the NCG-444 test series reflects the preliminary state of the mission documentation; most ISI's require that the on site documents be corrected by hand.

5. Reports

a. Sites were required to send several reports to central control points. Required reports included Status Messages, Post Launch Information Messages, Detailed Post Launch Reports, Radar Performance and Communication Technician records. The number and contents of these required reports resulted in much duplication and probably some unnecessary data preparation.

b. The mission documentation does not state titles, planned dates or distribution of the post-mission reports that summarize the performance of the network during a mission.

6. Countdown

a. The Network Countdown was quite adequate for the MA-4 mission and is probably appropriate to future MA missions.

b. The time requirements on the CNV FPS-16 during the T-5:00 to T-3:00 period were coordinated satisfactorily among the organizations issuing (F-0)-day counts; the radar is required, serially, to support (1) capsule beacon checks, (2) AMR slew checks, (3) CADFISS Roll Call and (4) to observe RF silence during the capsule destruct box hookup.

7. Miscellaneous

a. The site recordings were promptly removed from the site following the MA-4 mission. These records, or suitable copies, would be valuable to the site as training aids and to foster a critical analysis of the site performance. Each subsystem group might be expected to correlate the equipment performance and personnel operations with the over-all subsystem effectiveness.

b. The Command carrier was kept on at San Salvador (AMR) for 8 minutes 2 seconds after the time specified in the Command Handover Documentation through an operator error.

C. Personnel and Training

1. It was reported that M&O personnel at some sites had not been on site for a sufficient length of time to develop acceptable proficiency.

2. At several sites, the M&O Supervisor's operational proficiency is severely reduced by his administrative burdens. Unless the M&O Supervisor, during the two weeks prior to launch, can devote his full attention to the operational areas, which include equipment status, site/network drills, system tests, mission documentation, individual operator readiness, briefings and debriefings, the site's performance will be severely handicapped.

3. Site operational readiness could be improved, and confidence of site capabilities could be obtained, by supplementing orbital missions and network drills with instrumented aircraft visits scheduled on a periodic basis.

4. Several radar operator errors may be attributed to a lack of experience in tracking orbital vehicles. A site-by-site comparison of tracking performance indicated that VERLORT operators trained on the RAZEL simulation equipment (at BDA, CYI and MUC) were more capable than the operators that did not have this device on site.

5. ATS reports that a relief teletype operator has been added to the M&O team as previously recommended.

VII. ANALYSIS OF TELETYPE TRAFFIC

A. General

This section of the report summarizes the analysis of the speed and accuracy of teletype message flow during the MA-4 flight (NCG-444) and its previous simulation (NCG-444BB). The analysis is mainly based upon the TTY Message Summary Reports prepared by the observers at the various sites. These reports were submitted for the NCG-444BB simulation on September 11, 1961, and the NCG-444 (MA-4) mission. Tables were prepared from these reports which present the significant information in a concise form. The tables are complete, giving message data from lift-off to the end of the mission, except for Texas on Test NCG-444BB. This lack of a report from Texas on September 11, 1961, was due to damage from Hurrican Carla.

B. Traffic Analysis

The analysis was made in two ways: (1) information flow, and (2) message transmission time. The dual analysis was made to obtain measures of both the performance of the overall system, including applicable human factors, and the performance of the teletype system alone. Information flow, which deals with the overall system, is discussed first; followed by message transmission time, which reflects the teletype system performance alone.

1. Information Flow

Information flow time is defined as the interval between the delivery of a handwritten message to the communications room at the sending site, and the receipt of the completed message at the receiving site. The first Date-Time-Group on each message gives the time stamped on the handwritten message when it is delivered to the communications room. In the communications room a teletype operator takes the handwritten copy and prepares a punched tape which, when completed, is sent over the teletype circuit. At the receiving site the completely received message is torn off and then time stamped with the time of receipt. Both of these times, i.e., the first Date-Time-Group, and the received time stamp, are given in hours and minutes.

It will be noted from Table 7-1 for Test NCG-444 that the greatest proportion of the messages fall into the 0-5 minute information flow time class. Specifically, about 86%* of the messages are in the 0-5 minute class, 14% are in the 5-10 minute class and less than 0.5% are in the greater than 10 minute class. Since message processing at the sending site requires several minutes, the indicated performance was very good.

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*The percentages quoted throughout this section are exclusive of the undetermined messages which are assumed to be distributed in the same manner as those in the other columns.

Table 7-2 gives similar information flow data on Test NCG-444BB. It was noted that the total number of messages was considerably less (about one-half) for the simulation (444BB) as compared to the live mission (444). If percentages are considered instead of absolute numbers, a much closer agreement is evidenced. Specifically, the live mission placed 86%, 14%, <0.5% in the 0-5, 5-10, >10 minute classes respectively, and the simulation placed 89%, 10%, 1% in the 0-5, 5-10, >10 minute classes respectively.

2. Message Transmission Time

Message Transmission Time provides a measure of the performance of the teletype system alone, exclusive of most human factors. It is measured by determining the time interval between that given in the Date-Time-Group at the end of the message and the received time indicated by the time stamp at the receiving site.

The time indicated by the Date-Time-Group at the end of the message corresponds to the time when the teletype operator completed punching the message tape. If the message tape is immediately transmitted and the message is promptly time-stamped at the receiving site, the difference between these times is an accurate measure of the transmission time. These conditions were assumed in this analysis so that the reported measured times are equal to or greater than the actual message transmission times.

Message Transmission Time is composed of two parts. The first part is the time required to transmit the message. The second part is the delay that may be encountered en route due to circuit sharing, switching, transmission speed changes and ARQ error checking equipment. In general, the second part is considerably smaller than the first.

The right hand portion of Table 7-1 gives the Message Transmission data on the live mission (Test 444). It will be noted that a large portion of the messages fall into the lower time classes indicating short transmission times for a large number of messages. Many of the messages in the 0-1 and 1-2 minute classes have not experienced any significant delays because these times are commensurate with message lengths.

The right hand portion of Table 7-2 gives the Message Transmission data on the NCG-444BB simulation. It will be noted that a larger percentage of the messages fell into the lower time cells than on the live mission. Specifically, the live mission placed about 60% of the messages in the 0-1 and 1-2 cells combined, while the BB simulation placed about 79% in these cells. In other words, the data seem to indicate a greater percentage of longer message transmission times on the live mission day than on the simulation. Initially, it was thought that this was due to the increased load carried on the live mission day, which was almost twice that carried on the BB simulation day. However, further analysis is required to substantiate this hypothesis.

3. Lost and Garbled Messages

The proportion of garbled messages occurring during Test NCG-444 was small, being only about 0.5%. This was better than some of the previous network drills in which garbled messages represented 1%-3% of the total.

As in the case of the previous simulations, there were no lost messages reported for the live mission. This can be attributed to the excellent performance of the teletype system, including human factors, and the message accountability system.

4. Radar Data Messages

The performance of the teletype system was excellent in the timeliness of its handling of radar data. Although radar was missing from several sites on the live mission, it was not attributable to communications. Transmission delays* were quite small. It will be noted in Table 7-3 that the 6 raw-radar transmissions were delayed less than 10 seconds by the communications system. The transmissions showing greater delays were the smoothed radar data from the Bermuda computer and do not represent communication delays.

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*Transmission delay is defined as (T_1-T_0), where T_1 is the recorded time of receipt, at Goddard, of the first character of the message. T_0 is the time indicated in the first line of the radar message, which is the time the message started transmission from the sending site.

There was only 1 line out of 346 lines of radar data that contained an obvious error. This figure was obtained by examining the Goddard RO page copies of radar data for obvious errors, such as garbled line or letters in place of figures. It should be noted that errors that would change a digit from one value to another could not be determined in this way.

The delays and errors of radar messages for the Test 444BB network drill, shown on Table 7-3, are somewhat greater than for the live mission. It will be noted that no messages are in the 0-10 second class for the drill and 3 lines of 565 lines of radar data had obvious errors. The reason for the apparent increased delay during drills was the instruction to the sites to delay transmission of simulated radar tapes by at least 15 seconds.

C. Analysis of Telemetry Summary Messages

An important aspect of a TLM Summary (SUM) message is the timeliness of its receipt at the Mercury Control Center (MCC) and at succeeding sites. This message is important because it permits Flight Controllers to evaluate the state of the space vehicle and its occupant and to establish the trends of telemetered data and also provides capsule frequencies to the Maintenance and Operations (M&O) personnel prior to capsule contact. Table 7-4 shows the timeliness of delivery of the SUM messages during Test NCG-444.

The times listed in the tables are in minutes from lift-off. The first column gives the telemetry contact time, for example, Bermuda established telemetry contact with the capsule at 3 minutes and 4 seconds after lift-off. The second column gives the time of loss of the telemetry signal (LOS) at the sites. The third column gives the time of arrival of the SUM message at the communications center of the originating site. The fourth column is the difference between columns 2 and 3 which is the time interval between LOS at the site and arrival time of the SUM message at the communication center of the originating site. The fifth column gives the receipt time of the SUM message at MCC. This time, instead of the receipt time at all sites, was used because of its availability and its close approximation to the actual receipt time at other sites. This time is a close approximation since SUM messages are automatically broadcast outward from Goddard as they are coming in. The broadcast transmission lags the incoming message to be broadcast by about one second. Column 6 gives the first site to receive the SUM in time to extract its data prior to midpass of the capsule over the site. The seventh column gives the number of the first succeeding site in the capsule orbit, with reference to the originating site, that was able to use the SUM prior to capsule midpass.

It will be noted from Table 7-4, that in many cases the second succeeding site in the orbit was able to use the SUM message. In some cases, such as Zanzibar, the first succeeding site, i.e., the Indian Ocean Ship, received the SUM message prior to midpass. It should be noted that the Canary Islands site was able to use the Bermuda SUM message.

It should be noted that the SUM message from CTN was the last to be received prior to the capsule pass by all of the U.S. sites because of the close spacing of the sites. However, this would not affect range operations because all of these sites are connected by the Goddard Voice Conference Loop so that any abnormal data telemetered from the capsule would be quickly disseminated by voice as well as by SPE teletype messages.

The time from LOS to message delivery into the communications center at the originating site is a measure of the time used by the site in preparing its SUM message. This is shown in column 4 of Table 7-4. These times are of the same order as those obtained in network drills. To get a quantitative measure of comparison, average SUM message preparation times were obtained for each network drill from NCG-444G through Y and arranged in rank order as follows:

NCG-444E-2	6.2 mins.
NCG-444F-2	4.0 mins.
NCG-444E-1	3.9 mins.
NCG-444G	3.6 mins.
NCG-444F-1	3.0 mins.
NCG-444Y	1.8 mins.
NCG-444B	0.6 mins.

The average time from LOS to message delivery into the communications center at the originating site for the NCG-444 live mission was computed as 3.4 minutes. In terms of the above rank order it would fall between the F-1 and the G simulations.

The SUM messages, as well as others, are subject to delays, therefore the time interval from LOS to the receipt of the SUM message at MCC is significant, since it serves as a measure of the SUM message flow to all sites. Table 7-5 gives the times from LOS to the receipt of the SUM at MCC. Column 1 gives the times for the NCG-444 mission and column 2 gives the average times for the network drills NCG-444G through Y.

It will be noted that the times are comparable* with some sites being better for the live mission, and some being better for the network drills. For example, BDA is seen to be a little better for the live mission with a time of 6 minutes 22 seconds as contrasted with 7 minutes and 42 seconds for the network drills. ATS is noted to be slightly worse for the live mission. It was gratifying in the case of CYI to notice the much better performance for the live mission with a time of 5:40 as opposed to 9:36 for the average of the drills.

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*This was checked by applying a statistical significance test to the means of the two columns. No significant difference was revealed because the difference in the means was less than the difference expected in normal random sampling.

In general, the over-all performance of the man-machine system in handling SUM messages during the live MA-4 mission was quite comparable to the performances demonstrated during the previous network drills.

MERCURY MISSION
NCG-444
Wednesday, September 13, 1961

TABLE 7-1

ALL MESSAGES

Site Summary Report

Station No.	Code	Total Inbound Msgs.	INFORMATION FLOW TIME (Min.) C-5	5-10	>10	Undetermined	MESSAGE TRANSMISSION TIME (Min.) 0-1	1-2	2-3	3-4	4-5	>5	Undetermined	Garbled Msgs	Lost Msgs
1	MCC	180	151	16	0	13	89	49	17	7	2	2	14	2	0
2	BDA	67	63	4	0	0	46	14	3	1	2	0	1	2	0
3	ATS	59	50	9	0	0	6	21	21	6	3	2	0	0	0
4	CYI	59	48	11	0	0	7	20	16	9	4	2	1	0	0
5	KNO	58	55	3	0	0	27	18	9	1	2	0	1	0	0
6	ZZB	58	32	25	1	0	2	2	8	23	17	6	0	0	0
7	IOS	27	27	0	0	0	4	13	7	3	0	0	0	0	0
8	MUC	64	58	4	2	0	23	24	11	1	0	5	0	0	0
9	WOM	56	38	18	0	0	1	3	22	17	7	5	1	2	0
11	CTN	58	39	19	0	0	1	3	17	23	8	5	1	0	0
12	HAW	53	51	2	0	0	41	7	2	1	0	2	0	0	0
13	CAL	27	0	0	0	27	0	0	0	0	0	0	27	0	0
14	GYM	62	58	4	0	0	38	14	5	1	2	1	1	0	0
15	WHS	59	52	7	0	0	13	24	16	4	0	2	0	0	0
16	TEX	61	54	7	0	0	11	24	18	4	1	2	1	0	0
17	EGL	58	51	7	0	0	9	24	16	6	1	1	1	0	0
TOTAL		1006	827	136	3	40	318	260	188	107	49	35	49	6	0
GRAND TOTAL		1006		1006						1006				6	0

MERCURY MISSION
NCG-444 BB
Monday, September 11, 1961

TABLE 7-2

ALL MESSAGES

Site Summary Report

Station No.	Code	Total Inbound Msgs.	INFORMATION FLOW TIME (Min.) 0-5	5-10	>10	Undetermined	MESSAGE TRANSMISSION TIME (Min.) 0-1	1-2	2-3	3-4	4-5	>5	Undetermined	Garbled Msgs	Lost Msgs
1	MCC	117	107	6	1	3	78	23	4	4	0	5	3	0	0
2	BDA	41	38	3	0	0	25	10	3	0	2	0	1	0	0
3	ATS	37	31	6	0	0	16	8	3	6	1	2	1	0	0
4	CYI	39	23	13	3	0	5	9	7	4	3	11	0	0	0
5	KNO	38	34	3	1	0	22	11	1	0	2	2	0	0	0
6	ZZB	19	18	0	0	1	1	7	9	1	0	0	1	0	0
7	IOS	20	20	0	0	0	11	7	2	0	0	0	0	0	0
8	MUC	40	32	6	2	0	14	11	7	4	1	3	0	0	0
9	WOM	39	36	3	0	0	23	10	3	1	1	1	0	0	0
11	CTN	38	32	6	0	0	11	17	4	4	2	0	0	0	0
12	HAW	34	32	2	0	0	31	1	0	0	1	1	0	0	0
13	CAL	17	0	0	0	17	0	0	0	0	0	0	17	0	0
14	GYM	39	35	4	0	0	24	9	2	1	1	2	0	0	0
15	WHS	37	34	3	0	0	27	6	2	0	1	1	0	0	0
16	TEX	-	-	-	-	-	-	-	-	-	-	-	-	-	-
17	EGL	36	32	4	0	0	24	6	4	0	1	1	0	0	0
TOTAL		591	504	59	7	21	312	135	51	25	16	29	23	0	0
GRAND TOTAL		591		591						591				0	0

MERCURY MISSION

NCG444

TABLE 7-3

SUMMARY OF INCOMING RADAR DATA TO GSC

Mission No.	Date	Total Inbound MSGS	TRANSMISSION DELAY IN SECONDS 0-10	10-20	20-30	30-40	40-50	50-60	>60	Undetermined	Lines in Error	Total Lines
NCG444 BB	9/11/61	10	0	4	3	1	0	0	0	2	3	565
NCG444	9/13/61	8	6	0	0	0	1	0	1	0	1	346
TOTAL		18	6	4	3	1	1	0	1	2	4	911
GRAND TOTAL		18			18						4	911

TEST NCG 444 (MA-4)

TABLE 7-4

Wednesday, September 13, 1961

SUM MESSAGE FLOW

T-O=140416

SITE	CONTACT TIME IN MINS. FROM LIFT-OFF		LOS TIME IN MINS. FROM LIFT-OFF		SUM. TO COMM. CENTER IN MINS. FROM LIFT-OFF		DIFFERENCE BETWEEN COLS. 2 & 3	RECEIPT AT MCC IN MINS. FROM LIFT-OFF		FIRST DWN. RANGE SITE TO UTILIZE	NUMBER OF FIRST DWN. RANGE SITE W/R TO ORIGINATING SITE
	GMT	(min-sec*)	GMT	(min-sec*)	(pt DTG) GMT	(min-sec*)	(min-sec)	GMT	(min-sec*)		
CNV				06-42							
BDA	140720	03-04	141438	10-22	1419	14-	04-22	1421	16-44	CYI	2
ATS	141308	08-52	142001	15-45	1424	19-	03-59	1426	21-44	KNO	2
CYI	141842	14-26	142520	21-04	1428	23-	02-40	1431	26-44	ZZB	2
KNO	142529	21-13	143218	28-02	1437	32-	04-42	1441	36-44	IOS	2
ZZB	143423	30-07	144154	37-38	1443	38-44	01-06	1446	41-44	IOS	1
IOS	144425	40-09	145214	47-58	1454	49-44	01-46	1459	54-44	WOM	2
MUC	145326	49-10	150142	57-26	1505	60-44	03-18	1511	66-44	CTN	2
WOM	145825	54-09	150632	62-16	1511	66-44	04-28	1514	69-44	CTN	1
CTN	151425	70-09	1520	75-44	1525	80-44	05-00	1529	84-44	CAL	1
HAW	--	--	--	--							
CAL	152939	85-23	153547	91-31	1541	96-44	05-13	1544	99-44	BDA	6
GYM	153027	86-11	153710	92-54	1541	96-44	03-50	1543	98-44	BDA	5
WHS	153243	88-27	153808	93-52	1539	94-44	00-52	1543	98-44	BDA	4
TEX	153305	88-49	153955	95-39	1541	96-44	01-05	1546	101-44	BDA	3
EGL	1535	90-44	1541	96-44	1543	98-44	02-00	1549	104-44	BDA	2
CNV		93-06		96-58	1548	103-44	06-46	--	--		
BDA	154500	100-44	155348	109-32	1557	112-44	03-12	1603	118-44		

*Time after lift off.

MERCURY MISSION

TABLE 7-5

Wednesday, September 13, 1961

LOS TO RECEIPT OF SUM AT MCC

T-0=140416

Site	NCG-444 (min.: sec.)	Average of Network Drills for MA-4 (Min.:sec.)
CNV		
BDA	6:22	7:[illegible]2
ATS	5:59	4:54
CYI	5:40	9:36
KNO	8:42	6:24
ZZB	4:06	5:24
TOS	6:46	6:00
MUC	9:18	7:18
WOM	7:28	6:00
CTN	9:00	5:00
HAW		
CAL	8:13	8:42
GYM	5:50	7:00
WHS	4:52	3:00
TEX	6:05	6:42
EGL	8:00	5:00
CNV	--	
BDA	9:12	7:42

VIII. CADFISS TESTS

A. General

In this section of the report, the CADFISS Roll Call and Data Flow Tests conducted on Sept. 11 (NCG444BB) and Sept. 13 (MA-4 Mission Day) are reviewed. The Roll Call and Data Flow Tests conducted during earlier MA-4 simulations (Aug. 15 through Aug. 25) are included in the report for that period. The tests conducted on Sept. 9 (NCG444DD) were outside the observation periods, and are not included in either report. However, a quick review of results for Test NCG444DD indicated no unusual happenings.

The program and computers worked well during the CADFISS tests in the NCG444BB and NCG444. The same program was used as had been used during the August network drills. Site readiness, as measured by CADFISS tests, was good. On both days the CADFISS Roll Call and the Data Flow tests operated successfully and expeditiously.

Some confusion arose concerning the purpose and scheduling of the two Data Flow periods in the Network Count. The o. iginal intent was for these to be option periods - the choice of option being selected by the Network Status Monitor.

Possible options are:

1) Reruns of test failed during the Roll Call
2) Reruns of tests with sites indicating a change of status since the Roll Call
3) Data Flow confidence tests (These are series 40 radar tests, and would generally be run only if there were holds of substantial length, to insure that the data flow network had not deteriorated during the hold)
4) High speed tests between GSFC and MCC.

The intent of these Data Flow periods was apparently misinterpreted. It was later stated that network series 40 Data Flow tests were required by the Network countdown. To countermand this interpretation, ISI No. 16 (issued Aug. 22) stated that Data Flow periods were to be used only for tests failed during the Roll Call. This IS. was not followed on mission day, when network series 40 tests were run at T-0:50 following about one hour of holds. The recommended procedure for future missions is to state the options available and leave the decision to the Network Status Monitor.

B. Results by Site

This section summarizes CADFISS results at each site for the two days of tests.

BDA - The results of the 20 series tests of the primary teletype circuits (09 and 10) were good, while the back-up circuits (USAF-01 and USAF-02) had intermittent garbling. The VERLORT timed out on Roll Call test 41 in Test 444BB, but passed the rerun. An incorrect patch during the second Data Flow period during NCG444 resulted in time-outs for tests 41 and 42 on circuits 09 and USAF-01. The radar performance appeared satisfactory, since the time-outs were ascribed to non-radar causes.

ATS - All teletype tests were successes.

CYI - Teletype test results were better than during the earlier MA-4 simulations. Back-up circuit 16 via ATS had some garbling in Test 444BB, but only a single character error was noted from CYI in Test 444. The VERLORT radar tests were generally satisfactory.

KNO - All teletype tests were successes.

ZZB - Teletype tests on mission day were successes. A single character error was observed at GSFC in Test 444BB.

IOS - All teletype tests were successes.

MUC - A single character error was observed at MUC on circuit 01 in Test 444. All other teletype tests, and all radar tests were successes.

WOM - The teletype test in Test 444 was a failure on circuit 01 to WOM, with many errors noted. It was a success on circuit 02. In NCG444BB, teletype tests were successes on both circuits. Radar responses during NCG444BB were from precut tapes. They were live in NCG444 and were successful. WOM reported its FPS-16 "red" at 09:20GMT during

Test NCG444. For this reason, a rerun was requested in the first Data Flow period. This time the test (42 only) was successful.

CTN - A single character was received in error during teletype tests at GSFC in Test 444. Teletype tests were successful during Test 444BB.

HAW - All teletype tests were successes. Radar boresight tests were all successes in Test 444. During NCG 444BB IRACQ modifications to the FPS-16 prevented its participation. The site still does not have range targets for either radar.

CAL - All teletype tests were successes. All radar tests during NCG444BB were successes. On mission day (Test 444), tests 42 and 81 were failed during the Roll Call but were successes on the reruns. The trouble was attributed to circuit problems that developed after the 20 series tests.

GYM - All teletype and radar boresight tests were successful. The site does not have a range target.

WHS - All tests were successful. The radar responses to Roll Call tests 42 and 82 during NCG444BB were from precut tape since there was a radar-to-teletype equipment outage at that time. The reruns with live data during the Data Flow period were successful.

TEX - All tests were successes on mission day (Test 444). TEX did not participate in any tests in NCG 444BB because of Hurricane Carla.

EGL - All radar and teletype tests were successes.

C. Discussion of Results

The CADFISS test results and the site status reports both indicated a high degree of network readiness on the MA-4 mission day. The actual radar tracking results were not good. A question can therefore be asked of the usefulness of the CADFISS tests in predicting network readiness. It must be remembered, however, that many factors not tested by CADFISS are important to good radar performance. Among these are transmitter and receiver performance, dynamic response, and operator procedures and training. The first two of these are examined in the BST's and DST's. There is considerable evidence to indicate that the last of these causes was primarily responsible for the disappointing radar showing. The present CADFISS tests do serve useful functions in checking data flow paths (most importantly the radar-teletype and teletype-computer interfaces) and radar calibration.

Consideration should be given to inclusion of dynamic (slew) checks in the CADFISS Roll Call. CADFISS slew checks are available as 90 series tests but have been used only for non-mission tests. Tests 91 and 92 are clockwise and counterclockwise slew checks for the VERLORT radar; tests 93 and 94 are the same for the FPS-16 radar. Each test requires 40 frames, or four minutes, of radar data. Therefore, to run all slew tests with a dual radar site having only one teletype line would add at least 16 minutes to the running time of the Roll Call at that site. It would be desirable to have shorter slew checks for mission tests.

With slew checks of perhaps two minutes per test, it should be possible to complete a Roll Call in less than one hour, provided that reruns were deferred to a later test period.

The failures with CAL in the Roll Call test during NCG444 demonstrated that critical communication coverage had not been instituted at CAL at the time of the Roll Call test. Whether such coverage would have prevented the failure is debatable.

The time expirations at BDA during the last Data Flow period of Test NCG444 are somewhat disturbing. The cause of the time-outs was stated to be an incorrect teletype patch at BDA, and based on this information, no rerun was requested. The incorrect patch was made at the communications carrier terminal in Bermuda, not at the site. This raises doubt that the safeguards against such an incorrect patch are adequate. The Data Flow test was not expected to be run, and was run only because of holds in the count. It is possible that the incorrect patch would not have been discovered prior to lift-off if it had not been for the Data Flow test.

At least two messages were sent during the period in which teletype traffic was restricted for the second CADFISS Data Flow test of NCG444. These were a 1200Z GEN from ATS and a 1219Z STAT from GYM. Neither caused any apparent difficulties in the running of the Data Flow test. The first was received before the start of the test, and the second probably was sent after the finish of the test at GYM. However, the restricted period lasted from 1155GMT to 1226GMT. It is quite probable that short TTY messages would not interfere with CADFISS testing; empirical data should be obtained during network drills to determine the feasibility of this possible easing of the restrictions on TTY traffic during CADFISS tests.

APPENDIX A

Bermuda Telemetry Observations

The following are excerpts from a report* made to Bell Telephone Laboratories by Mr. T. J. Hoban of Sandia Corporation who observed the performance of the telemetry equipment at the Bermuda site for the (F-2)-day network drill and the Mercury-Atlas 4 (F-0)-day, September 11 and 13, 1961 respectively.

"1. Equipment Performance

MA-4 Mission, September 13 - A malfunction in the timing distribution system caused loss of the 1 per 6-second timing signals to the radar plotboards. A short hold resulted until it was discovered that timing signals were being recorded on the radar data being sent to GSFC and would not result in a loss of data. The mission was, therefore, completed without effecting repair. Otherwise, the MA-4 operation was extremely smooth with surprisingly few difficulties. Telemetry acquisition was made approximately 30 seconds earlier than was anticipated.

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*The report by Mr. T. J. Hoban also contained observations made during the MA-4 network drills in August, 1961 which were included as Appendix A of the "Report on Observations of the Mercury Ground Range during the MA-4 Network Exercises of August 15-25, 1961."

During the first overhead pass TLM contact was maintained for 8 minutes. Maximum signal strength was 600 microvolts, signal strengths at acquisition and loss-of-signal were reported as 150 microvolts. Except for two very short RF fades noted while monitoring the TMI signal analyzer, the signal quality was very good.

During the re-entry phase, TLM contact was again maintained for approximately 8 minutes. RF signal levels were considerably less than those received on the first pass and the last 3 minutes of contact were extremely intermittent, probably due to multipath reflections and perhaps capsule antennae pattern. The last telemetered signal to be positively confirmed was "Drogue Chute Deploy"; shortly after this time, RF fading became so severe and frequent that the decommutator was not able to maintain synchronization. Maximum signal strength was 250 microvolts on the low frequency link and 300 microvolts on the high frequency link.

2. Personnel Performance

Two of the TLM operators had been recently assigned to the telemetering operation and were somewhat lacking in experience; however, they handled their operational assignments well, except that adjustment of tape recorder levels during the MA-4 mission could have been made sooner and should have been monitored more frequently. Malfunctions which occurred during the countdowns were handled rapidly and with minimum confusion.

3. Procedures

Information is not available at all sites for annotation of the pen recorder charts per instructions in the MA-4 Data Acquisition Plan, in particular, Items 2 and 3.

4. Recommendations

Permission should be granted to the TLM station operators to playback the recorded magnetic tapes as a means of determining the quality of the actual recorded signals in comparison to the real time signals. Any degradation in quality (if any exists) of the recorded signal could then be noted and relayed to the data playback station. If problems in this area happen to exist, they would be immediately determined and corrected. Of course, if this permission were granted, extreme caution would be necessary to prevent accidental recording of other data on the tape.

There has been some difference of opinion expressed by MCC and BDA telemetry operators in regard to the desirability of operating the decommutators with or without the Zero and Gain correction servos. (cf. TWX messages 21/1559Z from Mr. L. E. Packham, dated 9/21/61). As I see the problem, the basic difference has to do with the recovery time of the decommutator during intermittent RF signal conditions. I believe that the BDA telemetry tape from the MA-4 (NCG-444) mission would be ideal for determining which mode of operation would be superior, because of the intermittent data received during the last three minutes due to RF fading. Playbacks of this tape with the servo system in and out should show whether more data is recovered without the servo in because of faster recovery of the sync circuits in this mode. The BDA decommutator was operated with the servo system in for Test NCG-444 and it is evident that during the last three minutes the decommutator was not in sync most of this time. Whether this would improve in the manual mode is unknown.

The benefits of operating with the servo in are: More accurate data is obtained and the operator's attention is not required for manual adjustment of the Zero and Gain correction. Operation without the servo will result in faster recovery of synchronization during RF dropouts and, therefore, a more significant amount of data may be obtained. However, manual adjustment may result in momentary loss of sync due to excessive movement of the controls and, of course, the data accuracy may suffer."

APPENDIX B

Observer Assignments for Test NCG-444BB and 444

September 11 and 13, 1961

SITE	OBSERVER	ORGANIZATION
MCC	P. Freeman	BTL
	J. Hibbert	BTL
	J. Johnson	BTL
	P. Johnson*	WECo
GSFC	C. Goodman	WECo
	A. Peterson	BTL
	G. Tolson*	WECo
BDA	T. Hoban	Sandia
	H. Kraus	BTL
	P. Lein	WECo
ATS	G. Adams*	WECo
LDN	J. Anderson*	WECo
CYI	M. Fabian*	WECo
MUC	H. Barrier*	WECo
WOM	D. Anderson	NASA
HON	N. Kulp*	WECo
GYM	J. Baldi	WECo
TEX	J. Kreer	BTL

*Indicates personnel already stationed on site for other duties.

APPENDIX C

Observers' Report Form

At the conclusion of each network exercise, the observers at each site were required to forward an "Observer Report" by teletype to MCC in the format shown in Figure C-1. This report contained the following information:

(1) Time of telemetry contact

(2) Time of loss of telemetry signal

(3) Duration of "solid" telemetry from the Capsule

(4) Duration of "solid" Acquisition Aid Tracking

(5) Duration of "solid" S-band radar tracking

(6) Duration of "solid" C-band tracking

(7) Duration of "solid" UHF voice

(8) Duration of "solid" HF voice

(9) Time of receipt of the following messages:

   a. Telemetry Summary (SUM)

   b. Acquisition and Pointing Data (AQ)

   c. Capsule Frequency messages (CRF)

   d. Retrofire Events (RTOF)

(10) Time of transmission of the following messages:

   a. Telemetry Summary (SUM)

   b. Contact (CON)

   c. Site Status (STAT)

(11) Qualitative evaluation of exercise

(12) Brief comments on the exercise

(13) Notation of any difficulties encountered

(14) Suggestions for changes

FIGURE C-1

Format of Observers' TTY Report

(date time group)
(MCC DE ----)
ADM
ATTN P. J. JOHNSON

OBSERVER REPORT FOR NCG-444 ----

1. DURATION (MIN-SEC)

A.	TM CON	----Z
B.	TM LOS	----Z
C.	TM SOLID	----
D.	AA SOLID	----
E.	S RADAR SOLID	----
F.	C RADAR SOLID	----
G.	UHF SOLID	----
H.	HF SOLID	----

II. TTY RECEIPT

A.	SUM	
	MCC	----Z
	BDA	----Z
	ATS	----Z
	CYI	----Z
	KNO	----Z
	ZZB	----Z
	IOS	----Z
	MUC	----Z
	WOM	----Z
	CTN	----Z
	HAW	----Z
	CAL	----Z
	GYM	----Z
	WHS	----Z
	TEX	----Z
	EGL	----Z
B.	ACQ 1	----Z
	2	----Z
	3	----Z
C.	CRF	----Z
		----Z
D.	RTOF	----Z

III. TTY TRANSMIT TIMES

A.	SUM	----Z
B.	CON	----Z
C.	STAT	----Z
		----Z
		----Z

IV. QUALITATIVE EVALUATION

V. COMMENTS

VI. DIFFICULTIES

VII. SUGGESTED CHANGES

APPENDIX D

Analysis of Radar Data Transmitted From Texas
During Test NCG-444

This report presents an analysis of the radar data transmitted from the VERLORT Radar at the South Texas site during the MA-4 mission on September 13, 1961. The analysis was made to determine the trouble areas in radar equipment, procedures and operation. The results show that difficulties were present in all three areas.

An inspection of the records of radar data transmitted to Goddard indicated three areas in which difficulty seemed to occur. They were inadequate procedural instructions, unsatisfactory operational technique, and equipment failure. The radar teletype print-out was converted to decimal values in nautical miles and degrees and plotted against time. The corresponding pointing data, corrected by adding to the time a constant amount to make a best fit to the intervals of valid data, were then plotted on the same sheets. The added constant corrected for the change (28 seconds) in orbital period due to the capsule being inserted in an orbit twelve miles lower than nominal and the fact that SECO occurred 9 seconds earlier than expected. With this correction, the lift-off time agrees within two seconds of the actually observed lift-off time.

Figure D-1 is the plot of the range data and Figure D-2 is the plot of the azimuth and elevation data sent from TEX, as received at Goddard. The solid curves on these figures correspond to the theoretical pointing data while the indicated points are derived from the teletype print-out.

Inspection of the azimuth curves indicates that the radar was actually tracking the capsule from 15:35:54Z to 15:36:12Z and from 15:38:36Z to 15:39:12Z. These intervals agree with the valid data bit on the teletype print-out. However, during the later interval, the elevation print-out contained all readings identically zero which would imply a pointing error relative to the calculated pointing data, of from two to six degrees. Even at the minimum error this was outside the beam width (2.4°) of the antenna by more than 0.8°. It is obvious that these print-out figures do not agree with the actual position of the antenna since it was tracking the capsule in range and azimuth, and this is emphasized by the fact that the elevation print-out is identically zero from 15:36:18Z to the end of transmission. Equipment difficulty apparently occurred in either the encoder or the digital-to-teletype converter, which seems to be confirmed by the report that the elevation strobe light in the encoder was later found to be defective.

The next observation is that the range in the data sent to GSFC is much shorter than predicted in the pointing data. However, the two curves are parallel and if two hundred nautical miles (corresponding to one period of the VERLORT PRF) are added to the radar range data the resulting curve is in good agreement, as indicated by the solid circles on Figure D-1. The errors remaining would be reduced to very small values if the change in orbital speed due to low altitude had been taken into account during the time of the pass (this correction would amount to about one second). It seems fairly obvious that after losing the target in coasting through the main bang at 15:36:10Z, it was reacquired at 15:38:36Z but with the range ambiguity resolution in error by the range equivalent to one pulse repetition period. The target should have been reacquired shortly after 15:38:24Z and tracked until 15:37:06Z, and then reacquired shortly after 15:37:16Z and tracked until 15:38:12Z. That this was not done was due to the fact that the operators allowed the antenna to shift for itself during the coast interval as is evidenced by the constant azimuth print-out for about 1.5 minutes starting at this time. Actually, as the pointing data show, the azimuth was changing very rapidly at this time and as a consequence the antenna was pointing ten or twenty degrees away from the capsule when it emerged from the coasting region.

Finally, the initial acquisition at 15:35:54Z was not accomplished until almost 2.5 minutes after appearance of the capsule on the horizon.

Taking up the difficulties in reverse order, the causes and what can be done to minimize their occurrence are now considered.

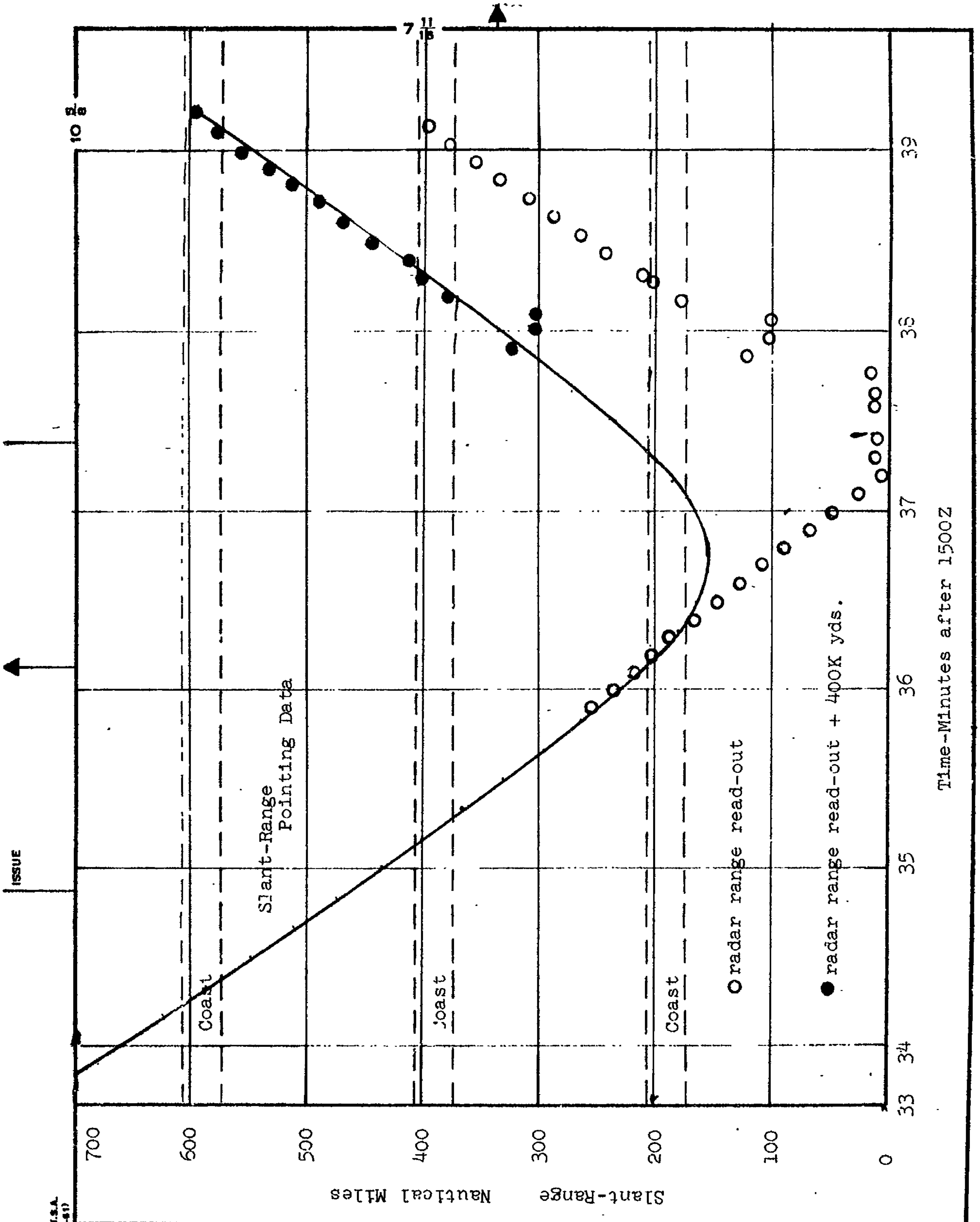
The late acquisition was almost certainly caused by the handover procedures which, as now described in Mercury Network Procedures (MNP)-Section VI, make no provision for an up-range station being unable to acquire. During the MA-4 mission, the VERLORT radar at Guaymas was unable to lock-on to the signal and consequently the Texas radar, although passively tracking the Guaymas signal, was unable to phase and under the procedures in MNP-VI could not start active track. These procedures should be modified so that under these circumstances the down-range station may request permission to track actively and the up-range station phase to it. This would probably have allowed Texas to start active tracking at least one minute earlier.

Next, the handover instructions in (MNP)-Section VI states that "During a VERLORT-to-VERLORT handover, both the tracking and acquiring radars will be locked in a PRF of 410, and the tracking radar will be obligated to coast through the main bang." Since the shortest time interval for passing the main bang is about four seconds and could be as long as one minute, while the coasting capability of the radar is only four seconds, the probability that the capsule will be lost during the coasting procedure is very high. Instead, the operators should use the available modes of operation to carry the radar through the main bang. This would include slaving the radar to the acquisition bus and using aided manual tracking in range to position antenna and range gate so as to reacquire as soon as the pulse emerges from the main bang. A better, but more expensive, solution would be to modify the counting chains so that once a PRF is properly phased it continues in that phase in spite of PRF changes, and then to allow the radars to change PRF in the normal manner.

Finally, the procedure for checking the range ambiguity resolution needs modification to insure proper range tracking. This could be done procedurally by assigning an operator to this task and requiring a continuing check. Alternatively, a minor equipment modification could be made to give the operator an unmistakable automatic alarm if the ambiguity were incorrectly resolved. This modification might consist of an "and" gate, with inputs from (1) the range ambiguity "brightener-pulse" and (2) the video output, to operate a relay which would light an alarm light, ring a bell, or, preferably, edge-light the safety glass over the main scope with a colored light so that the presentation would become colored if the range ambiguity were incorrectly resolved.

The remaining point is the reliability of the encoders and the digital-to-teletype converters. The cause of the failure at TEX should be determined and eliminated. If the reports of the failure being due to a defective strobe light prove to be true, this possibly could be rectified by providing two lights in parallel, each strong enough to trigger the pulse generating circuits.

This analysis has shown that a post-flight analysis of the tracking data, in conjunction with the theoretical pointing data, is a useful method of analyzing the performance of the radars at Mercury sites. It is recommended that this analysis be made for all sites.



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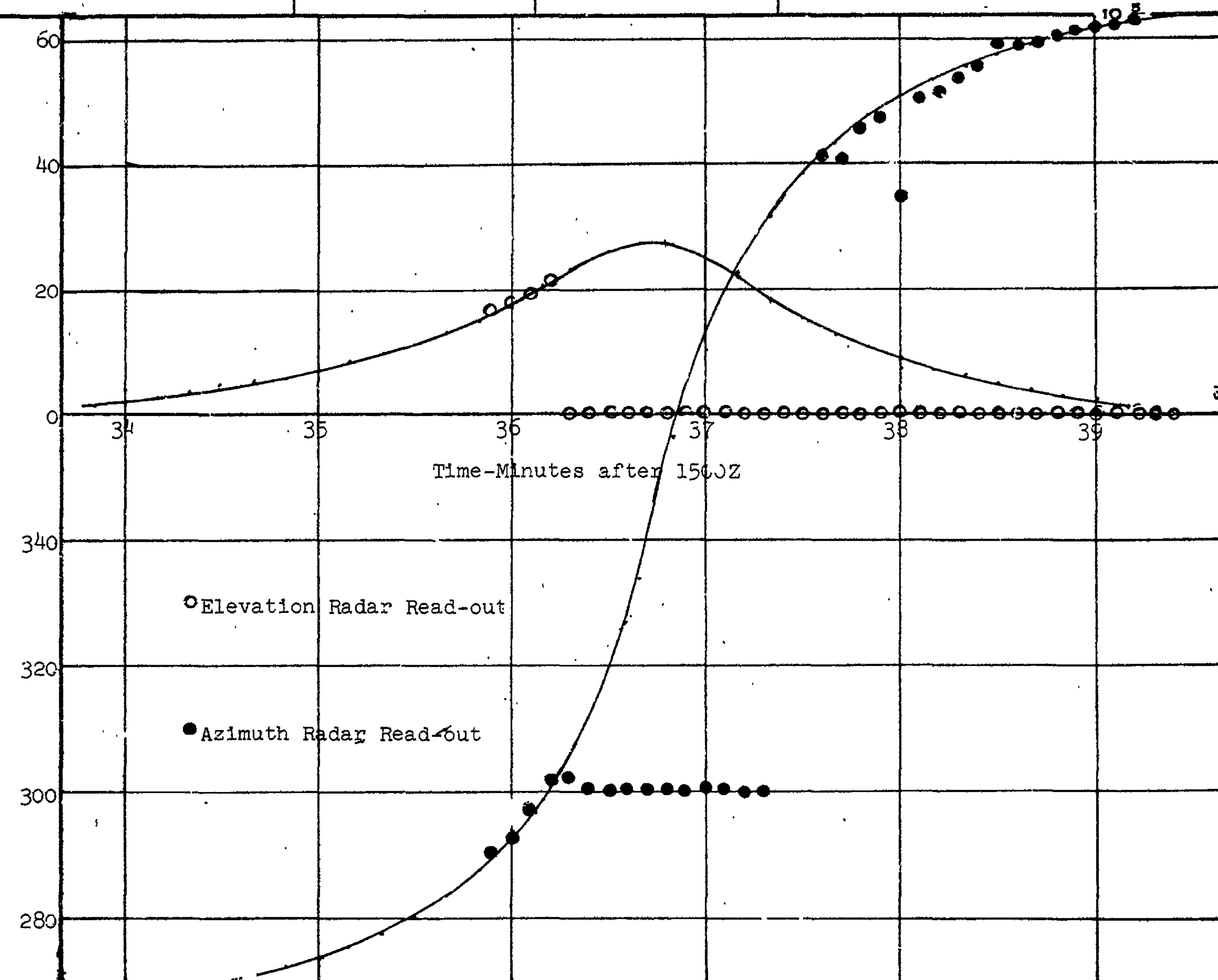
E-1812-A-1 (1-61)

ISSUE	ENGR	TITLE	BELL TELEPHONE LABORATORIES INCORPORATED
	DRAWN	Figure 1 Range vs Time TEX Radar Data During NCG-444	SHEET NO. OF SHEETS PER SET



PRINTED IN U.S.A.
E-1912-A-1 (1-61)

ISSUE	ENGR	TITLE	BELL TELEPHONE LABORATORIES INCORPORATED
	DRAWN	Figure 2 Azimuth and Elevation vs Time TEX Radar Data During NCG-444	NO. OF SHEETS PER SET · SHEET

APPENDIX E

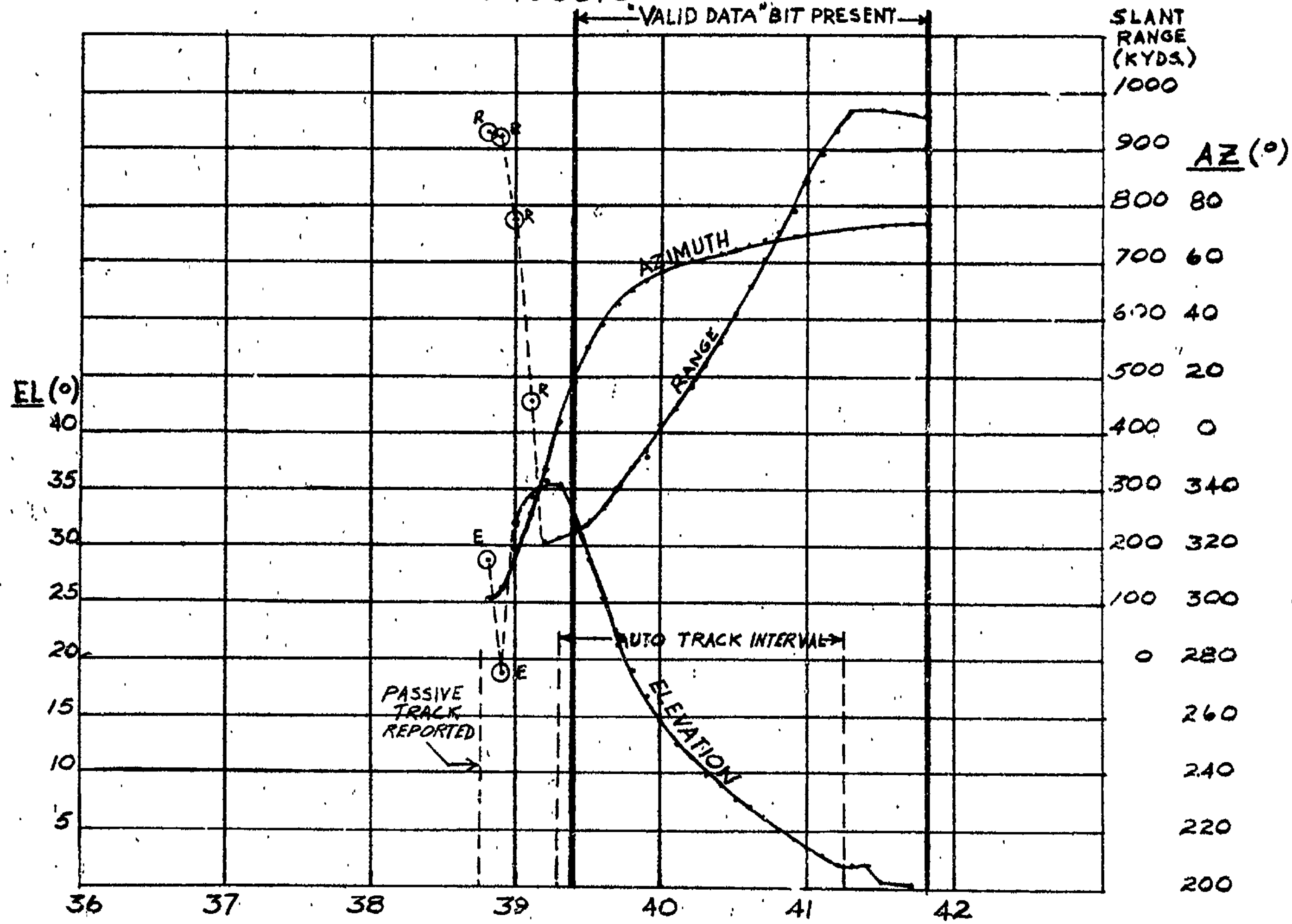
Analysis of Radar Data Transmitted From Eglin During NCG-444

The EGL FPS-16 radar supplied very good tracking data. The MPQ-31 radar had a defective transmitter, and was only able to track passively. Figure 7-1 shows the value of azimuth, elevation and range sent to GSFC by the FPS-16 radar at EGL. This information was used by the computer to obtain a very accurate impact point prediction.

EGL did not start tracking the capsule until near the time of closest approach. This delay is ascribed to the lack of a well-defined handover procedure with the [illegible]MS FPS-16. The start of automatic tracking by the EGL FPS-16 was reported to be at 15:39:17 GMT, and loss of signal at 15:41:15 GMT. However, the valid data bit remained in the data frames transmitted to GSFC until 15:41:48 GMT. It is apparent from Figure 7-1 that the data received at GSFC actually were invalid from LOS and that the computer received several frames of data which should not have been used. Since the predicted impact point was so close to the actual impact point, it appears that the computer program rejected most of these last frames.

It is intended that the valid data bit should drop out automatically when range track is lost. This obviously did not happen at EGL. One possible explanation for the malfunction is that the associated relay may not have been correctly adjusted, and did not drop out at LOS. Another possibility is that the mechanical decoder stop was reached before the capsule signal was lost. The LOS was reported by EGL to be at the end of the range gear train at maximum range. If it is possible for the capsule signal to stay in the range gate beyond this range, the valid signal could remain but the range decoder would be unable to advance. The range print-out indicates that the range remained essentially constant after LOS. It is recommended that the exact cause of this malfunction be determined. If the latter possibility should be correct, the valid signal logic should be changed to operate off the mechanical stops as well as the automatic track signal.

TEST NCG-444
EGLIN FPS-16 RADAR DATA SENT TO GSFC



E-3

ISSUE	ENGR	TITLE	BELL TELEPHONE LABORATORIES INCORPORATED
	DRAWN		NO. OF SHEETS PER SET / SHEET

APPENDIX F

TTY MESSAGE SUMMARY REPORT

MISSION NO. ____________ SITE ____________ DATE ____________

First DTG	To	From	Msg. Type	Circuit Used	Second DTG	Rec'd. Time Stamp	Remarks